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THE SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION PROGRAM

PROGRESS AND ACCOMPLISHMENTS FISCAL YEAR 1991

A Fifth Report to Congress

Office of Solid Waste and Emergency Response
Office of Research and Development
U.S. Environmental Protection Agency
Washington, D.C. 20460



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NOTICE

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PREFACE

The U.S. Environmental Protection Agency (EPA) established the Superfund Innovative Technology Evaluation (SITE) Program in 1986, following passage of the Superfund Amendments and Reauthorization Act (SARA). The Program's progress and accomplishments for Fiscal Year 1991 are presented in two sections in this Fifth Report to Congress. Section 1 presents an overview of the SITE program including the statutory authority and history of the program and the four program components and goals. Section 2 discusses the SITE program's progress and accomplishments over the past year and specific goals for the coming year.

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ACRONYMS

AAR	Applications Analysis Report
API	American Petroleum Institute
AETS	Acid Extraction Treatment System
ARAR	Applicable, or Relevant and Appropriate Requirements
AREAL	Atmospheric Research and Exposure Assessment Laboratory
ATTIC	Alternative Treatment Technology Information Center
BBS	Bulletin Board System
BDAT	Best Demonstrated and Available Technology
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERI	Center for Environmental Research Information
CES	Chemfix Environmental Services
CLU-IN	Clean Up Information Bulletin Board System (formerly OSWER Bulletin Board)
COLIS	Computerized On-Line Information System
CROW	Contained Recovery of Oily Waste
DCA	Dichloroethane
DOD	Department of Defense
DOE	Department of Energy
DQO	Data Quality Objectives
DSM	Deep Soil Mixing
DWS	Debris Washing System
EMSL-LV	Environmental Monitoring Systems Laboratory - Las Vegas
EPA	U.S. Environmental Protection Agency
ESD	Electroacoustic Soil Decontamination
ETP	Emerging Technologies Program
FTIR	Fourier Transform Infrared
FS	Feasibility Study
FY	Fiscal Year
GC/MS	Gas Chromatograph/Mass Spectrophotometer
HMCRI	Hazardous Materials Control Research Institute
HR-FT-IR	High Resolution Fourier Transform Infrared
HSWA	Hazardous and Solid Waste Amendments of 1984
IMS	Ion Mobility Spectrophotometer
IRF	Incinerator Research Facility
IWT	International Waste Technologies
JAWMA	Journal of the Air and Waste Management Association
KSU	Kansas State University
LDR	Land Disposal Restrictions
MAH	Monoaromatic Hydrocarbon
MBS	Methanotrophic Bioreactor System
MMTP	Monitoring and Measurement Technologies Program
MMS	Mobile Mass Spectrophotometer
NETAC	National Environmental Technology Applications Corporation
NPL	National Priorities List

ACRONYMS (Continued)

NTIS	National Technical Information System
OEETD	Office of Environmental Engineering and Technology Demonstration
OMMSQA	Office of Modeling, Monitoring Systems and Quality Assurance
ORD	Office of Research and Development
OSC	On-Scene Coordinator
OSWER	Office of Solid Waste and Emergency Response
OTA	Office of Technology Assessment
OTTERS	Office of Technology Transfer and Regulatory Support
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCP	Pentachlorophenol
PRP	Potentially Responsible Party
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
R&D	Research and Development
RD&D	Research, Development, and Demonstration
RFP	Request for Proposal
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Manager
RREL	Risk Reduction Engineering Laboratory
RTP	Research Triangle Park
SARA	Superfund Amendments and Reauthorization Act of 1986
SAB	Science Advisory Board
SITE	Superfund Innovative Technology Evaluation
S/S	Solidification/Stabilization
START	Superfund Technical Assistance Response Teams
STC	Silicate Technology Corporation
SVOC	Semivolatile Organic Compounds
T&E	Test and Evaluation
TCA	Trichloroethane
TCE	Trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TEM	Transient Electromagnetic Method
TER	Technology Evaluation Report
TIO	Technology Innovation Office
TIX	Technical Information Exchange
TOC	Total Organic Carbon
UCS	Unconfined Compression Strength
UV	Ultraviolet
VISITT	Vendor Information System for Innovative Treatment Technologies
VOC	Volatile Organic Compound

ABBREVIATIONS

cm	Centimeter
°F	Degrees Fahrenheit
kg	Kilogram
lbs	Pounds
mg	Milligram
mg/l	Milligram/Liter
mm	Millimeter
ppb	Parts Per Billion
ppm	Parts Per Million
psi	Pounds Per Square Inch
sec	Second

TRADE NAMES

AlgaSORB®
BioGensis™
BioVersal™
Chemfix
CHEMSET®
Decompozon
PACT®
RHM 1000
Tyvek®
Urrichem

EXECUTIVE SUMMARY

"The Superfund Innovative Technology Evaluation (SITE) program is the U.S. Environmental Protection Agency's (EPA) principal program to advance the development, evaluation, and implementation of innovative alternative technologies for the remediation of contaminated hazardous waste sites." This mission statement, established by EPA's Risk Reduction Engineering Laboratory (RREL), is fully compatible with the legislative mandate for the SITE program. The Superfund Amendments and Reauthorization Act of 1986 (SARA) directs EPA "to carry out a program of research, evaluation, testing, development, and demonstration of alternative or innovative treatment technologies . . . which may be utilized in response actions to achieve more permanent protection of human health and welfare and the environment" [SARA Section 209(b), Section 311(b)(1) of CERCLA].

The SITE program was the first major program for demonstrating and evaluating full-scale innovative treatment technologies at hazardous waste sites. Having concluded its fifth year, the SITE program is recognized as a leading advocate of innovative technology development and commercialization for hazardous waste treatment and remediation. In addition, through the demonstration of innovative monitoring and measurement technologies, EPA is promoting faster, more cost-effective site characterization and post-cleanup monitoring methods for Superfund and Resource Conservation and Recovery Act (RCRA) corrective action sites.

This fifth report to Congress documents the impact of the SITE program through discussing the program's progress and accomplishments over the past year. The report also sets goals for the coming years and makes specific recommendations on achieving those goals.

Use of Innovative Alternative Technologies

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by SARA, sets forth requirements for selecting remedies for Superfund sites. Remedial actions must:

- Be protective of human health and the environment.
- Attain or waive applicable, or relevant and appropriate requirements (ARAR).
- Be cost-effective.
- Use permanent solutions and alternative hazardous waste treatment technologies or resource recovery technologies to the maximum extent practicable.
- Satisfy the preference for hazardous waste treatment that reduces toxicity, mobility, or volume.

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Alternative treatment technologies are essential to meeting these requirements; however, sufficient information is often not available for a reliable analysis of alternatives using these technologies. Innovative alternative technologies may lack an established track record, have limited treatability and cost data and, as "unproven," may suffer public, state, and private (potentially responsible party) acceptance problems.

The SITE program is unique in its ability to generate appropriate and relevant information on innovative alternative technologies needed by remedial project managers, consultants, and other decisionmakers. SITE program data are recognized as reliable, high quality, and unbiased. The SITE testing and evaluation methods are founded in EPA's research programs, and yet include practical field experience.

SITE Program Progress and Accomplishments

The SITE Program is currently administered by the Office of Research and Development's (ORD) Risk Reduction Engineering Laboratory (RREL) in Cincinnati, Ohio. RREL's founding partner of the program, the Office of Solid Waste and Emergency Response (OSWER), established the Technology Innovation Office (TIO) to further advocate and promote the development and use of innovative treatment technologies in the public and private sectors. Likewise, RREL established its Superfund Technical Assistance Response Teams (START), the members of which are often SITE project managers as well, to aid the Regions on complex site remediation problems. Together, these three programs -- SITE, TIO, and START -- working as an integrated technical team, are a valuable source of information on the development and use of innovative treatment technologies for hazardous waste site remediation and corrective action.

Specifically, the SITE program integrates the following four components:

- Demonstration Program
- Emerging Technology Program
- Monitoring and Measurement Technologies Program (MMTP)
- Technology Information Services

Over the past year, SITE has conducted 11 field demonstrations of innovative treatment and monitoring and measurement technologies. Through fiscal year 1991 a total of 35 demonstrations have been completed or are ongoing at Superfund remedial and removal sites, private party cleanup sites, state cleanup sites, and EPA and developer test facilities. SITE developers have completed seven emerging technologies projects; three of these developers have been invited to participate in the demonstration program. In addition, 23 new technologies have been added to the demonstration program in 1991 and 13 to the emerging program. Currently, a total of 76 technologies are at various stages of completion within the SITE Demonstration program.

At the same time, EPA is attempting to attract additional technologies and sites into the program. Initiatives started last year with the Departments of Energy

and Defense (DOE and DOD) have resulted in three potential field demonstrations and an expanded emerging technologies program with co-funding from DOE.

Most important, studies by EPA and others show that the program is achieving positive results. Developers report increased client interest in their technologies, Superfund records of decision (RODs) are including the use of innovative treatment technologies, and Federal, state, and private remedial decisionmakers, as well as consultants, are relying on the SITE program for more cost and performance data for promising technologies.

SECTION I

SITE PROGRAM OVERVIEW

This section provides an overview of the SITE Program. The legislation mandating the formation of the SITE Program is discussed first, followed by a brief history of the program. The four components of the SITE Program are introduced in this section; a detailed discussion of the progress and accomplishments of each component is provided in Section II.

A. STATUTORY AUTHORITY

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Resource Conservation and Recovery Act of 1976 (RCRA) define the national programs for managing hazardous waste sites. The Superfund Amendments and Reauthorization Act of 1986 (SARA) specifically states a preference for remedial actions that permanently and significantly reduce the volume, toxicity, or mobility of hazardous substances and contaminants. The U.S. Environmental Protection Agency (EPA) is required to "select a remedial action that is protective of human health and the environment . . . and that utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable."

RCRA provides authority for EPA to require corrective actions for past releases at facilities receiving permits for treatment, storage, or disposal of hazardous wastes. Thus, an owner or operator of such a facility must clean up contamination resulting from current or past activities at the site. Also under RCRA, land disposal restrictions (LDRs) require that hazardous wastes be treated using "Best Demonstrated Available Technology" (BDAT)

for a specific waste before it can be disposed of in a land-based unit.

The Superfund Innovative Technology Evaluation, or SITE, program was formally established as a requirement of SARA. Section 311(b) of CERCLA, as amended by SARA, directs EPA to establish an "Alternative or Innovative Treatment Technology Research and Demonstration Program" including a field demonstration program for testing innovative treatment technologies at Superfund sites. In fulfilling this legislative mandate, EPA's SITE Program provides valuable information to environmental decisionmakers responsible for remediation of hazardous waste sites under both CERCLA and RCRA.

As required by Section 311(e), this report presents the program's accomplishments through Fiscal Year (FY) 1991. This report is the fifth annual report to Congress.

B. HISTORY OF THE SITE PROGRAM

As it prepared to reauthorize CERCLA, Congress required the Office of Technology Assessment (OTA) to review the Superfund program and to prepare a strategy for improving the program. One of the three principal goals of the review was "to understand future Superfund needs and how permanent clean-ups can be accomplished in a cost-effective manner for diverse types of sites."¹

¹ *Superfund Strategy*, U.S. Congress, Office of Technology Assessment, OTA-ITE-252, April 1985. Washington, DC.

The OTA study concluded that land disposal approaches, although proven technologies for their original applications in construction engineering, were not effective over the long term in containing hazardous wastes, nor were their immediate costs indicative of the likely long-term costs, including monitoring, operation and maintenance, and the costs of future clean-up actions, especially for cleaning up contaminated groundwater. The OTA report further concluded that not enough research, development, and demonstration (RD&D) efforts were devoted to innovative clean-up technologies and that many innovations existed, but few could overcome institutional and other barriers. Considering the high cost of the Superfund program, committing RD&D money for innovative clean-up and site characterization technologies could offer considerable economic advantages in the long term.

The Science Advisory Board's (SAB) Environmental Engineering Committee was concerned that enormous expenditures were being made under Superfund without an adequate technological database to support rehabilitation of hazardous waste disposal sites. In a formal resolution, the SAB committee expressed this concern to the EPA Administrator and to members of Congress who were considering amendments to CERCLA. The resolution recommended a comprehensive RD&D program to develop and demonstrate effective, long-term solutions.

The reauthorized CERCLA established an RD&D program for innovative alternative technologies. In response to the legislation, and after considering the reports and recommendations discussed above, ORD and OSWER developed a joint strategy for an RD&D program called the Superfund Innovative Technology Evaluation (SITE) program.

The following is a chronology of significant events in the development of the SITE Program:

- | | |
|--------------|--|
| March 1986 | EPA issues the first annual request for proposals to the SITE Demonstration Program (RFP SITE 001). Twenty technology developers respond to the RFP, and 13 are accepted into the program. |
| July 1987 | First SITE field demonstration is conducted. The Shirco Electric Infrared Incinerator is tested at the Peak Oil Superfund Site in Brandon, Florida. |
| July 1987 | EPA initiates the SITE Emerging Technology Program as a feeder to the demonstration program. Six developers are accepted into the program, each receiving up to \$150,000 per year for two years to develop and test their technologies at a laboratory- or pilot-scale. |
| January 1988 | The first SITE demonstration at an EPA test facility is conducted. American Combustion Technologies, Inc.'s Pyretron Oxygen Burner was demonstrated at EPA's Incineration Research Facility in Jefferson, Arkansas. |
| October 1988 | EPA co-sponsors the First International Symposium on Field Screening Methods for Hazardous Wastes and Toxic Chemicals. |

November 1988	EPA presents SITE findings at the Hazardous Materials Control Research Institute (HMCRI) Superfund '88 conference.	responsible for evaluating potential applications of innovative technologies and other outreach activities to promote their accelerated commercial development and use.
June 1989	EPA completes <i>A Management Review of the Superfund Program</i> (90-Day Study), which makes key recommendations for the SITE Program (see below).	
June 1989	OSWER and RREL sponsor the first <i>Forum on Innovative Hazardous Waste Treatment Technologies: Domestic and International</i> in Atlanta, Georgia, to help introduce promising international technologies through technical papers and poster displays and to showcase results of the SITE Program.	May 1990 RREL commissions a <i>SITE Program Participant Assessment</i> in conjunction with the <i>Second Forum on Innovative Hazardous Waste Treatment Technologies: Domestic and International</i> .
August 1989	EPA conducts the first demonstration under the Monitoring and Measurement Technologies Program. An immunoassay field kit for pentachlorophenol was demonstrated at the McGillis and Gibbs Superfund site, in conjunction with the Biotrol soil washing technology demonstration.	July 1990 RREL initiates the Superfund Technical Assistance Response Teams (START) program to provide long-term technical engineering support, including treatability studies, to assist EPA regional offices dealing with complex sites. START staff include SITE technical project monitors, enhancing RREL's outreach efforts.
December 1989	RREL demonstrates its debris washing system, developed by PEI Associates for EPA, at Superfund sites in Hopkinsville, Kentucky, and Lafayette, Georgia.	August 1990 RREL completes its internal <i>Management Review of the SITE Program</i> , which recommends program and legislative changes.
March 1990	OSWER establishes the Technology Innovation Office (TIO) with key staff from the SITE Program. TIO will be	September 1990 RREL initiates changes resulting from the management review.
		Summer 1991 RREL initiates joint SITE/START project at Anderson Development site.

C. PROGRAM COMPONENTS

Currently, the SITE Program is administered by the ORD RREL headquartered in Cincinnati, Ohio. The SITE Program integrates the following four component programs:

- Demonstration Program
- Emerging Technology Program
- Monitoring and Measurement Technologies Program
- Technology Information Services

In the **Demonstration Program**, innovative technologies are field-tested on hazardous waste materials. Engineering and cost data are gathered to assess whether the technology is effective for site clean-up. An Applications Analysis Report (AAR) is prepared to evaluate all available information on the specific technology and analyze its overall applicability to other site characteristics, waste types, and waste matrices. A second report, called the Technology Evaluation Report (TER), presents demonstration data such as testing procedures, performance and cost data collected, and quality assurance and quality control standards. Videos, bulletins, and project summaries are also prepared to further define and present demonstration results. This information is distributed to the user community to provide reliable technical data for environmental decisionmaking and to promote the technology's commercial use.

The Demonstration Program currently has 63 developers providing 76 innovative technologies for demonstrations. The projects are divided into the following categories: thermal destruction (8), biological degradation (15), physical and chemical (24), solidification/stabilization (10), physical/chemical - radioactive waste treatment (2), physical/chemical - thermal desorption (13), and materials handling (4). Several technologies

involve combinations of these treatment categories. Figure 1 shows the breakdown of technologies currently in the Demonstration Program. In FY 1991, 10 technologies were evaluated at Superfund remedial and removal sites, private party clean-up sites, state clean-up sites, and EPA and developer test facilities; 26 reports and bulletins have been published, and others are in various stages of production.

Before a technology can be accepted into the **Emerging Technology Program (ETP)**, sufficient data must be available to validate its basic concepts. The developer then conducts laboratory- and pilot-scale testing of the technology under controlled conditions to develop equipment and operating parameters. The technology's performance is documented, and a report is prepared. If bench and pilot test results are encouraging, the developer may be invited to participate in the Demonstration Program.

Currently, 44 technologies are in the ETP. These technologies can be divided into the following categories: thermal destruction (7), physical and chemical (21), solidification/stabilization (2), biological degradation (10), and materials handling (4). These projects vary from electroacoustical decontamination to laboratory- and pilot-scale studies of a laser-stimulated photochemical oxidation process. Figure 2 displays the breakdown of technologies in the ETP.

The **Monitoring and Measurement Technologies Program (MMTP)** explores new and innovative technologies for assessing the nature and extent of contamination and evaluating clean-up levels at Superfund sites. Effective measurement and monitoring technologies are needed to accurately assess the degree of contamination at a site; provide data to determine impact to public health and the environment; supply data to help select the most appropriate remedial action; and monitor the

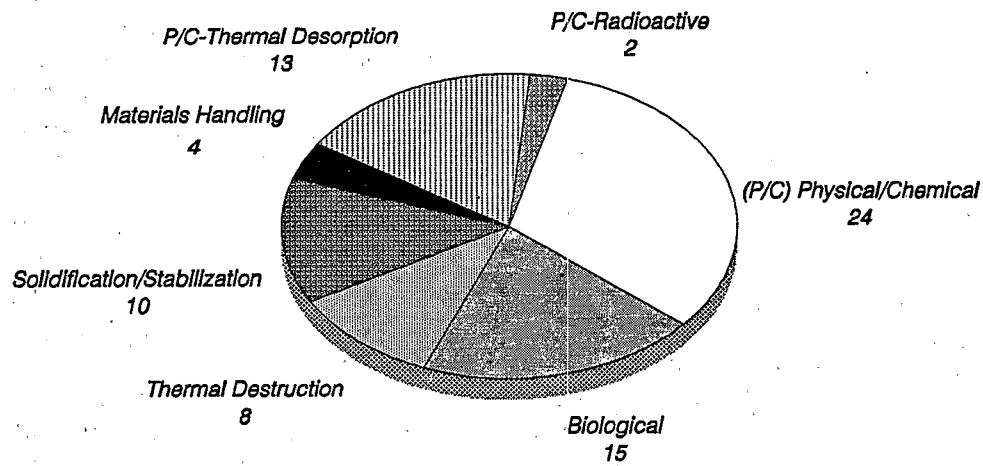


Figure 1: Innovative technologies in the Demonstration Program

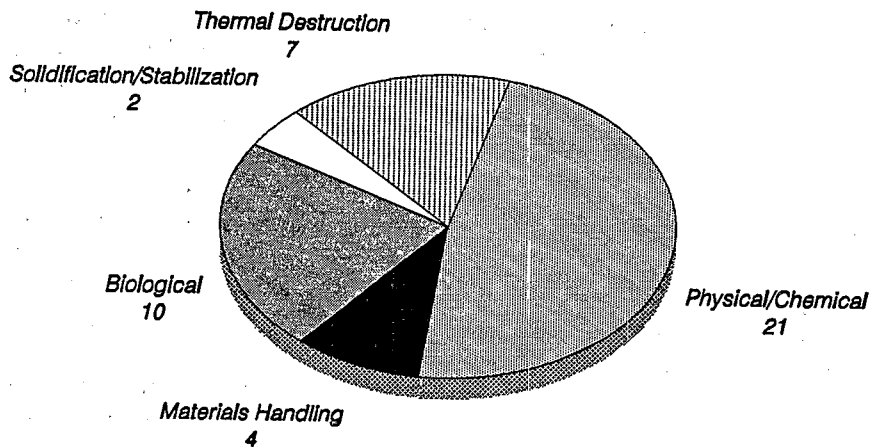


Figure 2: Innovative technologies in the Emerging Technology Program

success or failure of a selected remedy. The objectives of the MMTP are to:

- Identify existing technologies that can enhance field monitoring and site characterization.
- Support the development of monitoring capabilities that current technologies cannot cost-effectively address.
- Demonstrate technologies that emerge from the screening and development phases of the program.
- Prepare protocols, guidelines, and standard operating procedures for new methods.

One monitoring technology was demonstrated in FY 1991 -- an automated system for the sampling and analysis of water samples containing volatile organic compounds. In late FY 1991, planning began for the implementation of two FY 1992 technology demonstrations -- an immunoassay field kit for the analysis of benzene, toluene, and xylene (BTX) in water, and seven air monitoring technologies at the French Limited Superfund site.

In February 1991, EPA sponsored the *Second International Symposium on Field Screening Methods for Hazardous Wastes and Toxic Chemicals* in Las Vegas, Nevada. The Departments of Defense and Energy, the National Institute for Occupational Safety and Health, and others co-sponsored this important technology transfer activity.

Technology Information Services includes various technology transfer activities that support the SITE Program. Data results and status updates from the Demonstration and Emerging Technology Programs are disseminated to increase awareness of alternative technologies available for use at Superfund sites. The goal of these activities is to promote communication among individuals requiring up-to-date technical information, through various media, including:

- SITE brochures, publications, reports, videos, and fact sheets
- Monthly articles in the Journal of the Air and Waste Management Association (JAWMA)
- Pre-proposal conferences on SITE solicitations
- Public meetings and on-site Demonstration Visitors' Days
- Seminar series with regions and states
- Support for the Third Forum on Innovative Hazardous Waste Treatment Technologies: Domestic and International (June 1991).
- Exhibits displayed at national environmental conferences
- Networks established through associations, centers of excellence, regions, and states
- Technical assistance to regions, states, and clean-up contractors
- On-line information clearinghouses such as:
 - OSWER CLU-IN [Help line: 301/589-8368]
 - Alternative Treatment Technology Information Center (ATTIC) [System operator: 301/670-6294]
 - Technology Information Exchange/Computer On-line Information System (TIX-COLIS) [System Operator: 908/906-6851]

SECTION II

PROGRESS AND ACCOMPLISHMENTS

This section discusses the progress and accomplishments of the SITE Program over the past year. The program's overall accomplishments to foster incentives and overcome barriers are discussed first. This is followed by discussions of the progress of the four major components of the SITE Program: (1) the Demonstration Program; (2) the Emerging Technology Program; (3) the Monitoring and Measurement Technologies Program; and (4) Technology Information Services.

A. DEMONSTRATION PROGRAM

The goal of the SITE Program is to ensure, to the maximum extent possible, that innovative, alternative technologies are developed, demonstrated, and made commercially available for the permanent cleanup of Superfund sites. Through the program, EPA provides accurate and reliable performance, engineering, and cost data on the technologies for potential users. Within this framework, the Demonstration Program selects technologies for participation in a rigorous evaluation that are either at the final stage of field-scale development with hardware available, or fully developed with all equipment ready for use in the field. Emphasis is placed on innovative, alternative technologies which have been developed to the extent that a demonstration will lead to the application and commercialization of the process. The technology demonstration provides performance data and operating cost data, enabling potential users to make decisions on the applicability of the technology for a specific site and to compare the technology to similar alternatives.

The scale of demonstrations is flexible to accommodate the wide variety of technologies

expected to join the program. The criteria for determining the scale are based on the priority to provide data that are acceptable from both the QA/QC and the user community perspectives. The preference, however, is for field-scale demonstrations at Superfund sites.

Technology demonstrations may be conducted at federal or state Superfund sites (remedial or removal action sites), federal facilities, EPA Test and Evaluation (T&E) facilities, private sites, or the developer's facility. Generally, Superfund sites do not require permits; however, if necessary, EPA may assist a developer in acquiring necessary permits, or in substantially meeting the requirements of a permit, for demonstrations conducted at Superfund sites or federal facilities. All permits should be in place before selecting any other facilities for a demonstration. Proposals for a demonstration at a developer-owned facility should show that permits are in place prior to acceptance of the technology into the SITE Program. The criteria for selecting a site are established by the Office of Research and Development (ORD) in conjunction with the developer, the Office of Solid Waste and Emergency Response (OSWER), and EPA's regional offices.

In general, the developer is required to operate the technology at the selected location. EPA is primarily responsible for the development of the demonstration plan and is fully responsible for all sampling and analytical activities as well as all reporting. The developer and EPA must agree to the content of the demonstration plan, which consists of four major sections: an Operation Plan; a Sampling and Analysis Plan; a QA/QC Plan; and a Health and Safety Plan.

By the end of FY 1991, the Demonstration Program had completed six solicitations for new technologies. Since 1986, a new Request for Proposals (RFP) has been issued at the beginning of each calendar year to notify developers about the SITE Program and to define the needs of the program. For 1991, the solicitation emphasized:

1. Treatment of mixed, low level radioactive waste in soils and groundwater.
2. Combinations of unit operations to create treatment trains for specific wastes and waste site conditions.
3. Material handling techniques which improve pre-treatment and post-treatment operations.
4. Biological technologies for soil and sludge capable of treating organic contaminants.
5. In situ treatment processes for soil.
6. On-site treatment for large volumes of soil with relatively low contaminant concentration levels.
7. Treatment of soil, sludge and sediment containing organic and inorganic constituents.
8. In situ groundwater remediation techniques, including bioremediation for volatile organic compounds, which provide alternatives to long term pump and treat approaches to remediation.

The 1991 RFP further noted that specific pollutants identified by EPA's regional offices as needing technologies for remediation include lead, pentachlorophenol (PCP), polynuclear aromatic (PNA) compounds, tars and dioxins in soils and sediments. Petrochemical wastes with high levels of volatiles also were noted posing significant problems during construction,

excavation, and other material handling activities.

Sites in which EPA expressed special interest for cleanup included lead battery recycling sites and wood preserving sites. Developers having unit operations or complete treatment systems oriented toward solving remediation needs at these sites were encouraged to submit proposals and to note on these proposals a desire to tackle one of these problem areas.

At the end of FY 1991, the Demonstration Program included 76 technologies offered by 63 developers. Twenty-nine of these technologies have been (or are currently being) demonstrated; about 20 more are scheduled to be demonstrated in FY 1992. A complete list of Demonstration Program participants is presented in Appendix B.

The Demonstration Program can best be measured by (1) its ability to attract technologies and sites into the program, (2) the success of completed demonstrations in dealing with hazardous wastes, (3) the circulation of published program and technology information, (4) and the quality and variety of new projects. The following sections explain each criterion.

1. Soliciting New Technologies and Sites

As noted last fiscal year, and as recommended by several reviewers of the program, selection of technologies for FY 1991 was more flexible than in any past year. This does not mean that selection for the program has been made easy and less technically rigorous. Rather, the program has been more selective in evaluating proposals but more open to innovative ideas. Of the 23 technologies accepted for the program during FY 1991, a smaller number came from the formal advertisement of the RFP; a much larger number consisting of unsolicited contacts by developers. The program has made itself known through publications, symposia, and

technology exhibitions, and interested developers have responded with requests to join the program. SITE personnel have also been involved in a concerted effort to discuss the needs of the SITE Program with the regions and other federal agencies to obtain technology and site nominations.

Even though some requests for acceptance into the SITE Program may be outside the timeframe for the annual formal solicitation, the same acceptance criteria apply. Technologies are selected based on their readiness and suitability for field-scale demonstration, their applicability to Superfund situations, and their potential for commercialization. The following outline lists the acceptance criteria:

I. Technology Factors

- A. Description of the Technology
- B. Description of the Equipment
 - 1. Physical Appearance
 - 2. Unit Size and Transportability
 - 3. Treatment Capacity (throughput range)
 - 4. Availability
- C. Waste Streams Treated
 - 1. Contaminants
 - 2. Media
 - 3. Problem Wastes
 - 4. Concentrations of Feed and Product Streams
- D. Material Handling Needs
 - 1. Delivery and Removal Equipment
 - 2. Pre- and Post-Treatment Requirements
- E. Types and Quantities of Waste Streams or Residues Generated
 - 1. Gases and Particulates
 - 2. Liquids
 - 3. Solids and Sludges

II. Performance Factors

- A. History or Background of Process Development
- B. Pilot- or Field-Scale Test Data
- C. Applicability to Superfund Sites
- D. Advantages Over Similar Technologies

III. Developer Factors

- A. Experience and Availability of Assigned Key Personnel
- B. Company Profile
 - 1. Superfund-Related Experience
 - 2. Internal Support
 - 3. Anticipated Subcontracting Needs
- C. Capability to Commercialize
 - 1. Marketing Strategy
 - 2. Projected Unit Cost of Treatment

Locations for demonstration projects still depend in large part on nominations by EPA's regional offices. This process is being facilitated, however, through three SITE Program activities. First, notices are sent to the regions listing new technologies and highlighting those needing sites. Second, regional contacts within the SITE Program have been established to assist in communication. One person is assigned to each region to be the SITE focal point for the Remedial Project Managers (RPM), the Office of Technology Transfer and Regulatory Support (OTTERS) liaison position, and the Regional SITE Coordinator. Third, the Program continues to work closely with the Superfund Technical Assistant Response Team (START) Program to keep abreast of current problem sites and technical assistance needs.

Another resource for locating applicable sites has been federal facilities. Special emphasis has been placed on coordinating the

SITE Program with the needs of the Departments of Defense (DOD) and Energy (DOE). One demonstration in FY 1991 was accomplished at an Air Force site, and FY 1992 plans are firmly set for three demonstrations at DOE facilities, three at Air Force bases, and one at a Navy facility.

Finally, several vendors entering the program in FY 1991 came to EPA with candidate sites in mind or with ongoing cleanup contracts. As SITE personnel explain the program and talk to interested parties, they emphasize the fact that commercial jobs or vendor-nominated sites may ease the burden of site selection and speed the conduct of a demonstration.

2. FY 1991 Technology Demonstrations

During FY 1991, ten technologies were evaluated in the field. Of these ten, three evaluations that began in FY 1991 will continue into FY 1992. One of these, Hughes Environmental, Inc., is a commercial application that will last for several months. The second, an evaluation of EPA's fungal degradation process, will continue into the 1992 growing season with a full scale evaluation based on results of preliminary testing begun in summer 1991. The third, SBP Technologies, was initiated in August of 1991, but technical difficulties forced delay in completion. These ten technologies are summarized below, along with a brief discussion of the field performance.

Dehydro-Tech Corporation. East Hanover, NJ. The Carver-Greenfield Process® is designed to separate materials into their constituent solid, oil (including oil-soluble substances), and water phases. It is intended mainly for soils and sludges contaminated with oil-soluble hazardous compounds. The technology uses a food-grade carrier oil to extract the oil-soluble contaminants (see Figure 3). Pre-treatment is necessary to achieve particle sizes of less than ¼ inch.

The carrier oil, with a boiling point of 400 degrees Fahrenheit (°F), is typically mixed with waste sludge or soil, and the mixture is placed in an evaporation system to remove any water. The oil serves to fluidize the mix and maintain a low slurry viscosity to ensure efficient heat transfer, allowing virtually all of the water to evaporate. Oil-soluble contaminants are extracted from the waste by the carrier oil. Volatile compounds present in the waste are also stripped in this step and condensed with the carrier oil or water. After the water is evaporated from the mixture, the resulting dried slurry is sent to a centrifuging section that removes most of the carrier oil and contaminants from the solids. After centrifuging, residual carrier oil is removed from the solids by a process known as "hydroextraction." The carrier oil is recovered by evaporation and steam stripping. The hazardous constituents are removed from the carrier oil by distillation. This stream can be incinerated or reclaimed. In some cases, heavy metals in the solids will be complexed with hydrocarbons and will also be extracted by the carrier oil.

The demonstration of this technology was completed in August 1991 at EPA's facility in Edison, New Jersey. Petroleum wastes (drilling muds) from the PAB oil site in Abbeville, Louisiana were used for the demonstration. Preliminary results indicate a successful separation of oily drilling muds into their constituent oil, water, and solid phases.

ECOVA Corporation. Redmond, WA. ECOVA's slurry-phase bioremediation (bioslurry) technology (see Photograph 1) is designed to biodegrade creosote contaminated materials by employing aerobic bacteria that use the contaminants as their carbon source. The technology uses batch and continuous flow bioreactors to process polycyclic aromatic hydrocarbon (PAH) contaminated soils, sediments, and sludges. Because site-specific environments influence biological treatment, all chemical, physical, and microbial factors are

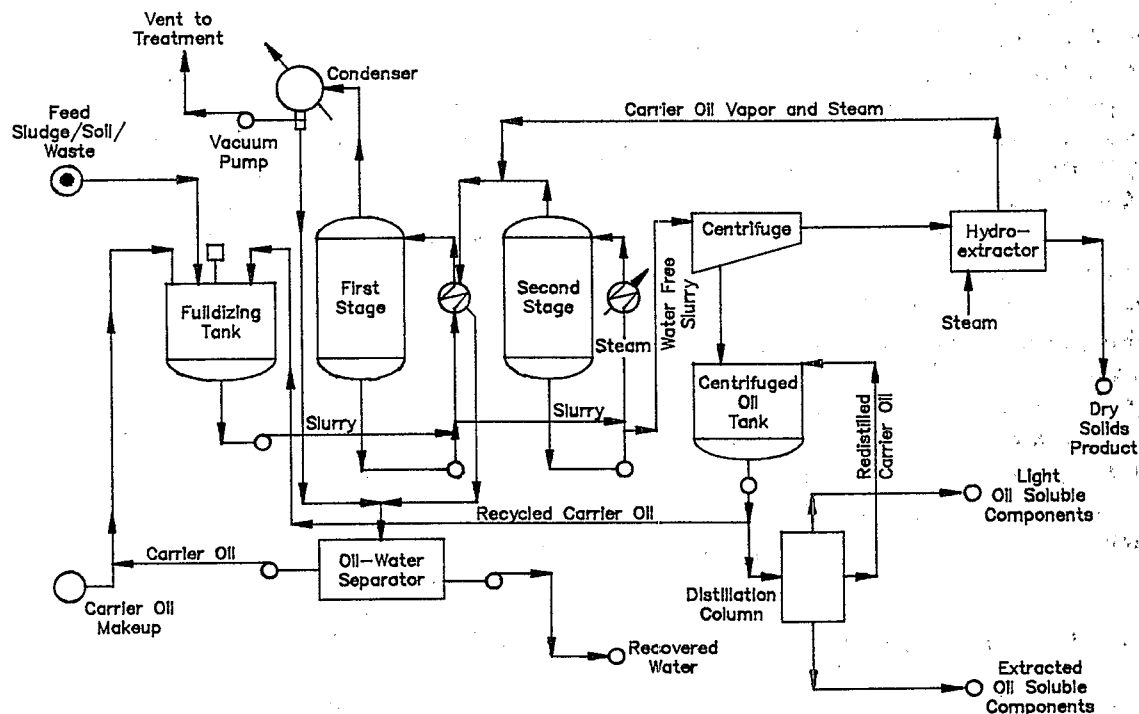
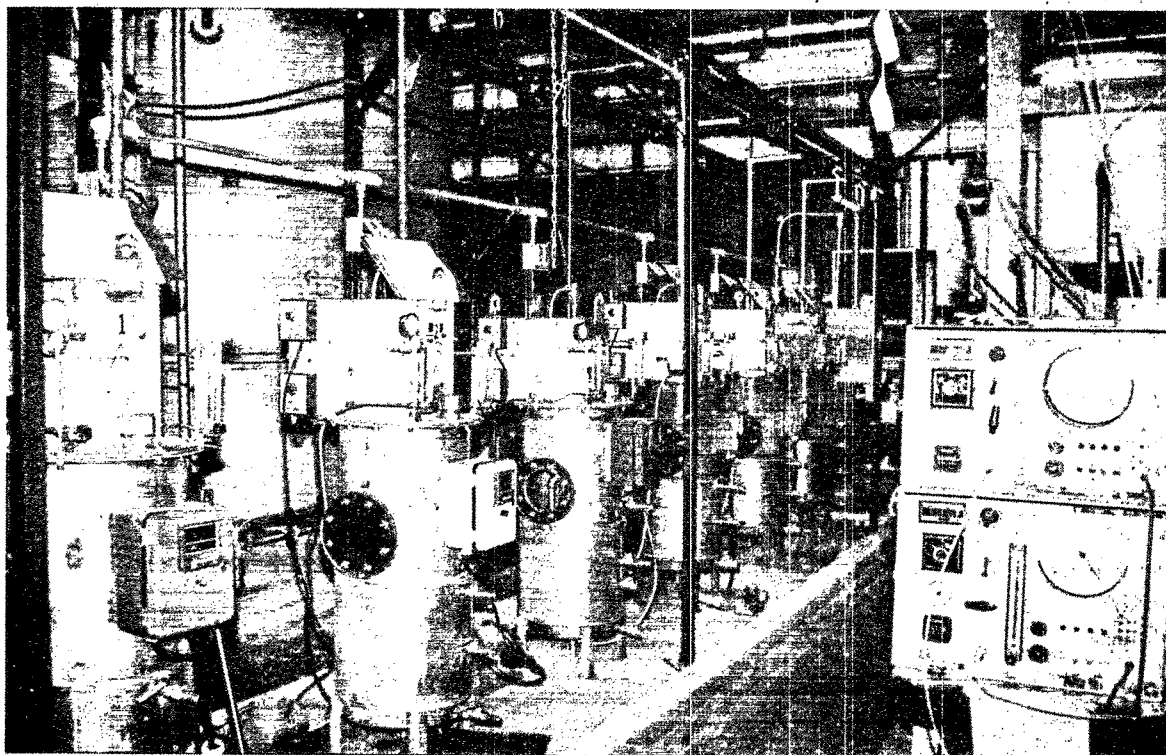


Figure 3: Dehydro-Tech Corporation's carver-greenfield process^o



Photograph 1: ECOVA Corporation's slurry-phase bioremediation technology

designed into the treatment process. The ultimate goal is to convert organic wastes into biomass, relatively harmless byproducts of microbial metabolism, such as carbon dioxide, methane, and inorganic salts.

ECOVA Corporation conducted bench- and pilot-scale process development studies using a slurry phase biotreatment design to evaluate bioremediation of PAHs in creosote contaminated soil collected from the Burlington Northern Superfund site in Brainerd, Minnesota. Bench-scale studies were performed prior to pilot-scale evaluations to determine the optimal treatment protocols. Data obtained from the optimized pilot-scale program will be used to establish treatment standards for K001 wastes as part of the EPA's Best Demonstrated Available Technology (BDAT) program.

Slurry-phase biological treatment was shown to significantly improve biodegradation rates of 4- to 6-ring PAHs. The bioreactors are supplemented with oxygen, nutrients, and a specific inocula of microorganisms to enhance the degradation process. Biological reaction rates are accelerated in a slurry system because of the increased contact efficiency between contaminants and microorganisms.

The technology was accepted into the SITE Demonstration Program in spring 1991 and from May through September 1991, EPA conducted a SITE demonstration using six bioslurry reactors at EPA's Test and Evaluation Facility in Cincinnati, Ohio. The reactors processed creosote-contaminated soil taken from the Burlington Northern Superfund site in Brainerd, Minnesota. Results from the pilot-scale bioreactor evaluation showed an initial reduction of 89.3 percent of the total soil-bound PAHs in the first two weeks. An overall reduction of 93.4 percent was seen over a 12-week treatment period.

Horsehead Resource Development Co., Inc. Monaca, PA. The flame reactor process (see Figure 4) is a patented, hydrocarbon-fueled, flash smelting system that treats residues and wastes containing metals. The reactor processes wastes with a hot (greater than 2,000 degrees Celsius [$^{\circ}\text{C}$]) reducing gas produced by the combustion of solid or gaseous hydrocarbon fuels in oxygen-enriched air. In a compact, low-capital cost reactor, the feed materials react rapidly, allowing a high waste throughput. The end products are a nonleachable slag (a glass-like solid when cooled), a recyclable, heavy metal-enriched oxide, and a metal alloy. The achieved volume reduction (of waste to slag plus oxide) depends on the chemical and physical properties of the waste. The volatile metals are fumed and captured in a product dust collection system; nonvolatile metals condense as a molten alloy. The remaining trace levels of metals are encapsulated in the slag. The elevated temperature destroys organic compounds. In general, the process requires that wastes be dry enough (up to 5 percent total moisture) to be pneumatically-fed, and fine enough (less than 200 mesh) to react rapidly. Larger particles (up to 20 mesh) can be processed; however, the efficiency of metals recovery is decreased.

The SITE demonstration was conducted March 18-22, 1991 on secondary lead soda slag from the National Smelting and Refining Company Superfund site in Atlanta, Georgia. The test was conducted at the Monaca facility under a Resource Conservation and Recovery Act (RCRA) Research Development and Demonstration permit that allows the treatment of Superfund wastes containing high concentrations of metals but only negligible concentrations of organics. About 72 tons of contaminated materials were processed from 48,200 to 61,700 mg/kg, but was reduced in the slag to a range of 1,560 to 11,400 mg/kg. The product oxide contained lead ranging from 159,000 to 180,000 mg/kg. All effluent slag passed the toxicity characteristic leaching procedure (TCLP) criteria.

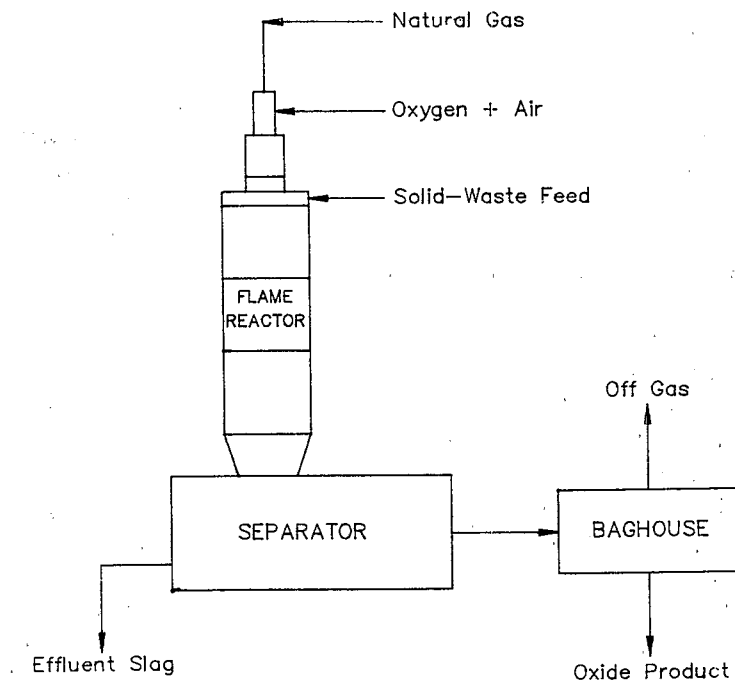


Figure 4: Horsehead Resource Development Company, Inc.'s flame reactor process

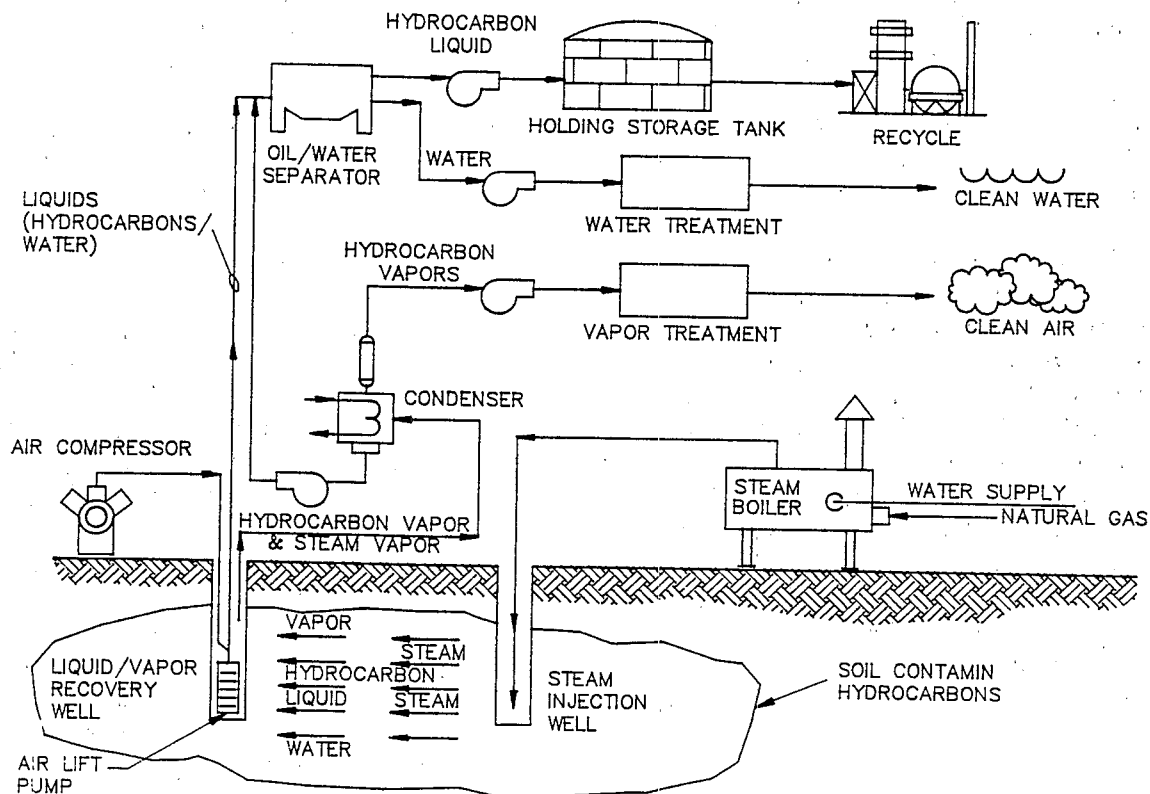


Figure 5: Hughes Environmental Systems, Inc.'s steam injection and vacuum extraction (SIVE) process

Hughes Environmental Systems, Inc. Manhattan Beach, CA. The steam injection and vacuum extraction (SIVE) process (see Figure 5), developed by Hughes Environmental Systems, removes most volatile organic compounds (VOC) and semivolatile organic compounds (SVOC) from contaminated soils in situ, both above and below the water table. The technology is applicable to in situ remediation of contaminated soils well below ground surface and can be used to treat below or around permanent structures. It also accelerates contaminant removal rates and can be effective in all soil types. Steam is forced through the soil by injection wells to thermally enhance the vacuum process. The extraction wells have two purposes: to pump and treat groundwater, and to transport steam and vaporized contaminants under vacuum to the extraction well and then to the surface. Recovered contaminants are either condensed and processed with the contaminated groundwater or trapped by gas-phase activated carbon filters. The technology uses readily available components, such as extraction and monitoring wells, manifold piping, vapor and liquid separators, vacuum pumps, and gas emission control equipment.

The SITE demonstration, currently underway at a site in Huntington Beach, California, began in August 1991 and will be completed in March 1992. The soil at the site was contaminated by a 135,000-gallon diesel fuel spill.

Retech, Inc. Ukiah, CA. Plasma Arc Vitrification occurs in a plasma centrifugal furnace by a thermal treatment process where heat from a transferred arc plasma creates a molten bath that detoxifies the feed material (see Photograph 2). Organic contaminants are vaporized and react at temperatures of 2,000 to 2,500°F to form innocuous products. Solids melt and are vitrified in the molten bath at 2,800 to 3,000°F. Metals are retained in this phase. When cooled, this phase is a nonleachable, glassy residue which meets the TCLP criteria.

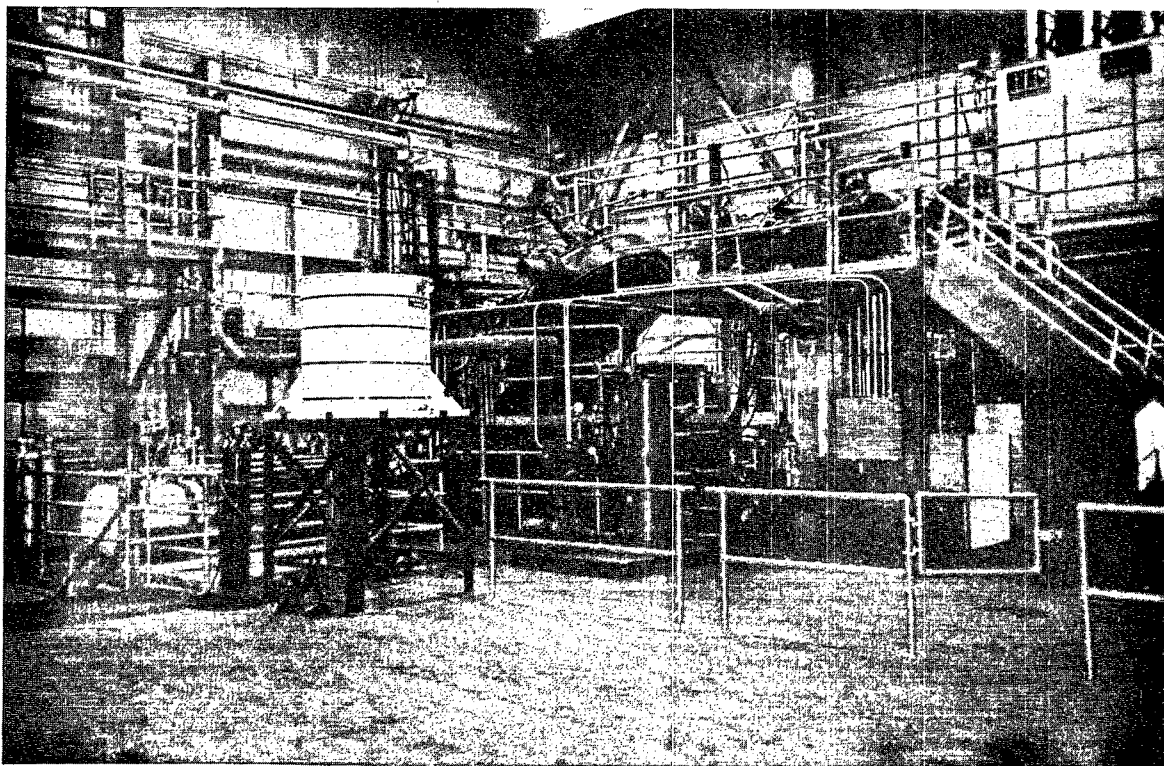
Contaminated soils enter the sealed furnace through the bulk feeder. The reactor well rotates during waste processing. Centrifugal force created by this rotation prevents material from falling out of the bottom and helps to evenly transfer heat and electrical energy throughout the molten phase. Periodically, a fraction of the molten slag is tapped, falling into the slag chamber to solidify.

Off-gas travels through a secondary combustion chamber where it remains at 2,000 to 2,500°F for more than 2 seconds. This allows the complete destruction of any organics in the gas. After passing through the secondary combustion chamber, the gases pass through a series of air pollution control devices designed to remove particulates and acid gases.

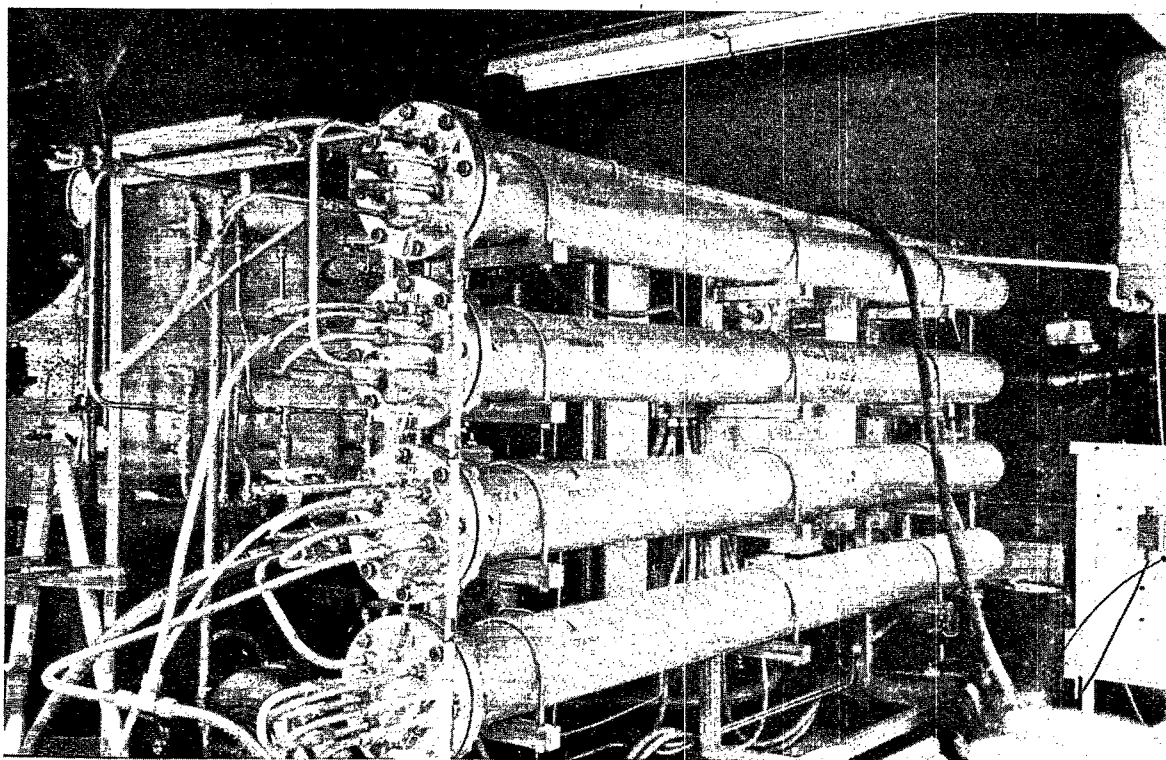
The SITE demonstration was conducted in July 1991 at a DOE research facility in Butte, Montana. During the demonstration, the furnace processed approximately 4,000 pounds of waste. All feed and effluent streams were sampled to assess the performance of this technology.

Risk Reduction Engineering Laboratory, U.S. EPA. Cincinnati, OH. The fungal degradation system utilizes white rot fungi to treat soils in situ. Because these organisms can break down lignin in wood, they may also be able to break down other recalcitrant compounds. As a result, the white rot fungi have been investigated over the past several years in the laboratory and have been shown capable of degrading certain organic contaminants such as pentachlorophenol (PCP). To take advantage of this response, wood chips and organic material inoculated with the fungi are mechanically mixed into the contaminated soil; the fungi break down the target contaminants as they break down the wood.

Because this technology uses a living organism (the fungi), the greatest success occurs with optimal growing conditions. Additives enhance growing conditions and may be required



Photograph 2: Retech, Inc.'s plasma arc vitrification process



Photograph 3: SBP Technologies, Inc.'s membrane hyperfiltration unit

for successful waste treatment. Moisture control is necessary; temperature control may also be needed. Wood chips may be added to the process to decrease the toxicity of the soil. Nutrients, such as peat, may also be added to provide a source of organic carbon.

The technology is typically used to treat soil contaminated with chemicals found in the wood preserving industry. Contaminants include chlorinated organics and polycyclic aromatic hydrocarbons. Different contaminants and combinations of contaminants may have varied degrees of success. In particular, the SITE Demonstration Program is evaluating how well white rot fungi degrade PCP. Field treatability tests were undertaken in August and September 1991 to determine whether the Brookhaven Wood Preserving site in Brookhaven, Mississippi would be suitable for a demonstration. The fungi have reduced PCP levels in the soil at this site, and if detailed analytical data and site characterization data prove positive, a large scale demonstration is expected to start in early spring 1992.

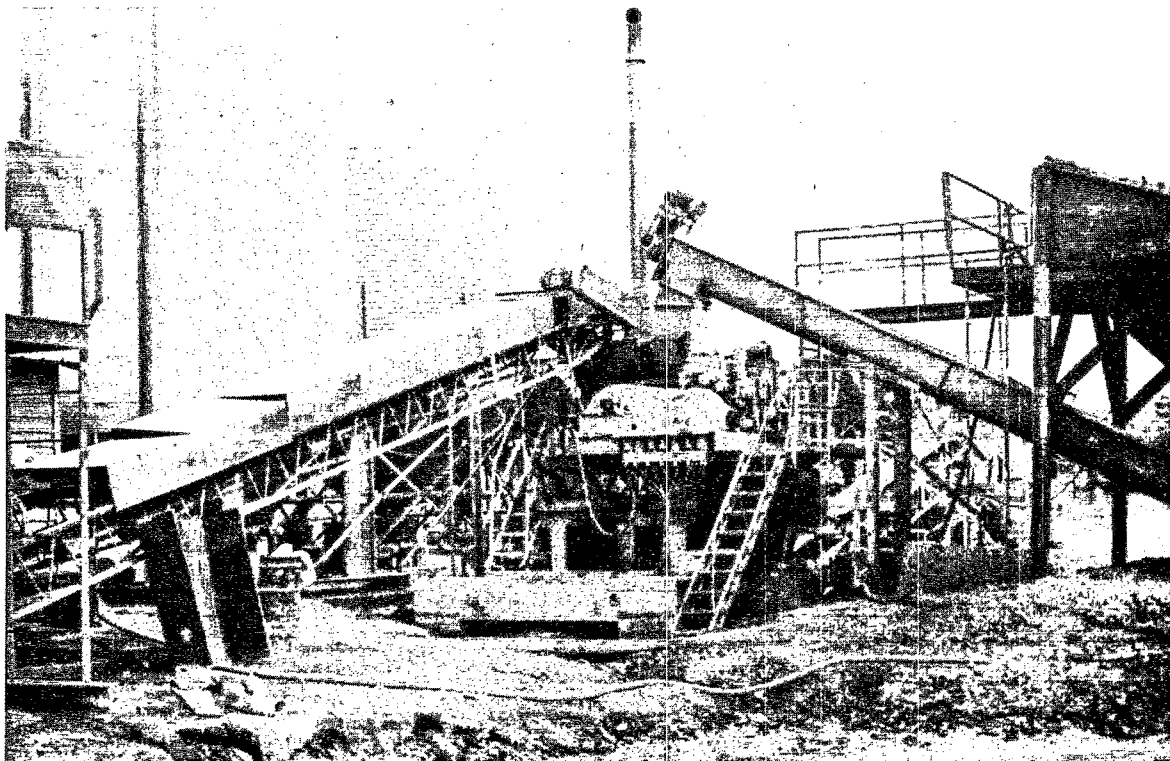
SBP Technologies, Inc. Stone Mountain, GA. SBP Technologies, Inc. (SBP), has developed a hazardous waste treatment system consisting of (1) a filtration unit for extraction and concentration of contaminants from groundwater, surface water, or slurries and (2) a bioremediation system for treating concentrated groundwater and soil slurries. These two systems are designed to treat a wide range of waste materials separately or as part of an integrated waste handling process.

The membrane hyperfiltration unit (see photograph 3) can remove and concentrate contaminants by filtering contaminated groundwater through a specially developed membrane. Depending on local requirements and regulations, the filtered water can be discharged to the sanitary sewer for further treatment at a publicly owned treatment works (POTW). The concentrated contaminants are collected in a holding tank. The bioreactor,

using a proprietary microorganism mixture, can biologically destroy concentrated contaminants and can produce effluent with low to nondetectable levels of contaminants. Integrating the two units will allow many contaminants to be removed and destroyed on site.

The first demonstration, on the filtration unit, occurred in September and October 1991 on creosote-contaminated groundwater. During testing, PAH removal was sufficient to pass local POTW discharge standards.

Silicate Technology Corporation. Scottsdale, AZ. Silicate Technology Corporation's (STC) technology (see Photograph 4) for treating hazardous waste utilizes silicate compounds to solidify and stabilize organic and inorganic constituents in contaminated soils, sludges, and wastewater. STC's organic chemical fixation/solidification technology involves the bonding of organic contaminants into the layers of an alumino silicate compound. STC's inorganic chemical fixation/solidification technology involves the formation of insoluble chemical compounds, which reduces the overall reagent addition compared to generic cementitious processes. Pre-treatment of contaminated soil includes separating coarse and fine waste materials and crushing coarse material, reducing it to the size required. The screened waste is weighed, and a predetermined amount of silicate reagent is added. The material is conveyed to a pug mill mixer where water is added and the mixture is blended. Sludges are placed directly into the pug mill for addition of reagents and mixing. The amount of reagent required for solidification and stabilization can be adjusted to the organic and inorganic contaminant concentrations determined during treatability testing. Treated material is placed in confining pits for on-site curing or cast into molds for transport and disposal offsite.



Photograph 4: Silicate Technology Corporation's organic chemical fixation/solidification technology

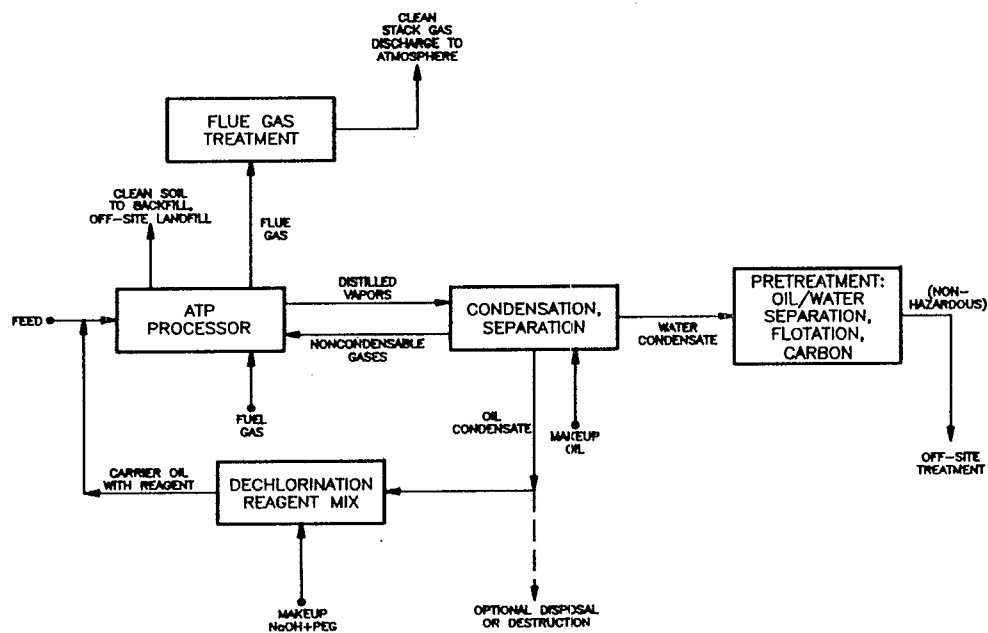


Figure 6: Soiltech, Inc.'s anaerobic thermal processor

The technology was demonstrated in November 1990 at the Selma Pressure Treating (SPT) wood preserving site in Selma, California. The SPT site was contaminated with both organics, mainly pentachlorophenol (PCP), and inorganics, mainly arsenic, chromium and copper. The demonstration indicated that STC's technology can treat PCP and immobilize arsenic, chromium and copper.

SoilTech, Inc. Englewood, CO. The SoilTech anaerobic thermal processor (ATP) (see Figure 6) is a thermal desorption process. It heats and mixes contaminated soils, sludges, and liquids in a special rotary kiln that uses indirect heat for processing. The unit desorbs, collects, and recondenses hydrocarbons from solids. The unit also can be used with a dehalogenation process to destroy halogenated hydrocarbons through a thermal and chemical process.

When the ATP is used to dechlorinate contaminants, the contaminated soils are sprayed with an oil mixture containing an alkaline reagent and polyethylene glycol, or other reagents. The oil acts as a carrier for the dehalogenation reagents. In the unit, the reagents dehalogenate or chemically break down chlorinated compounds, including polychlorinated biphenyls (PCB).

The technology will be involved in two SITE demonstrations. In May 1991, the first demonstration used a full-scale unit on soils contaminated with PCBs at the Wide Beach Development Superfund site in Brant, New York. The second demonstration, scheduled for spring 1992, will use a full-scale unit at the Outboard Marine Corporation site in Waukegan, Illinois.

The preliminary SITE Demonstration test results from Wide Beach indicated that:

- The SoilTech ATP unit removed over 99 percent of the PCBs in the contaminated soil, resulting in PCB levels below the

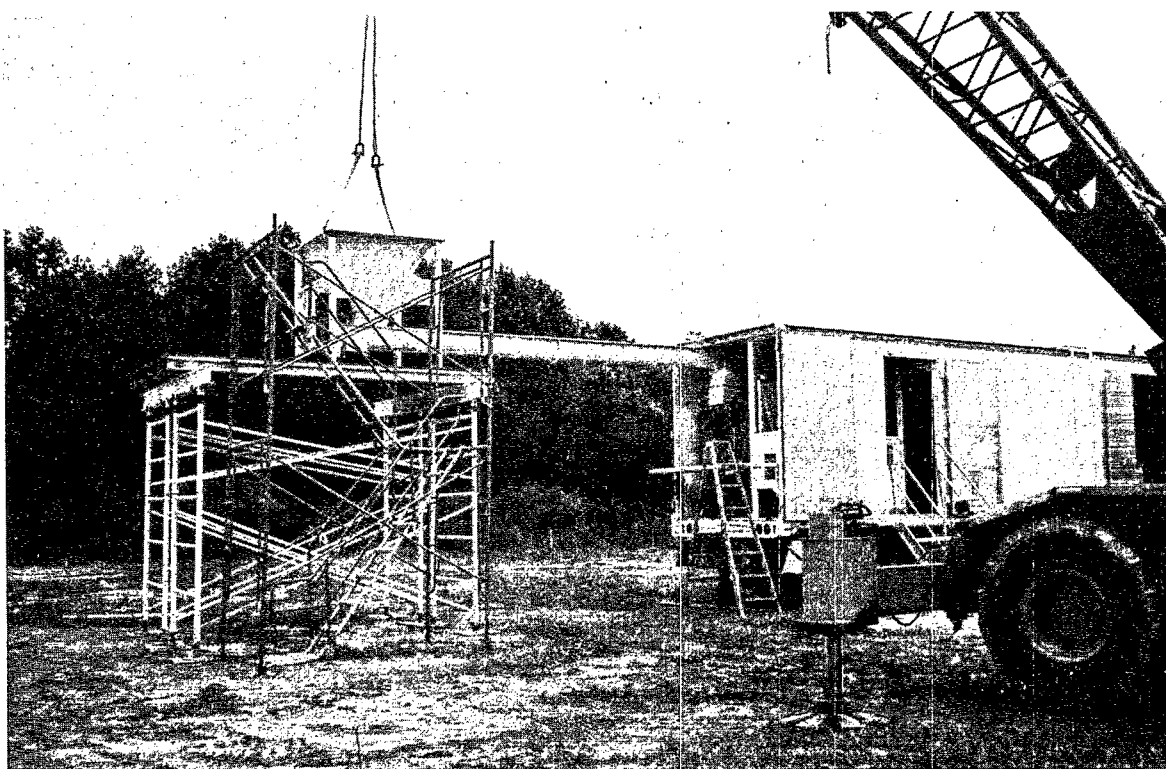
desired cleanup concentration of 2 parts per million (ppm).

- The SoilTech ATP does not appear to create dioxins or furans.
- No volatile or semivolatile organic degradation products were detected in the treated soil. No leachable volatile organic compounds (VOCs) or semivolatile organic compounds (SVOCs) were detected in the treated soil.
- No operational problems affecting the ATP's ability to treat the contaminated soil were observed.

WASTECH, Inc. Oak Ridge, TN. This solidification and stabilization technology applies proprietary bonding agents to soils, sludge, and liquid wastes with organic and inorganic contaminants to treat the pollutants within the wastes. The waste and reagent mixture is then mixed with cementitious materials, which form a stabilizing matrix. The specific reagents used are selected based on the particular waste to be treated. The resultant material is a nonleaching, high-strength monolith.

The process uses standard engineering and construction equipment. Since the type and dose of reagents depend on waste characteristics, treatability studies and site investigations must be conducted to determine the proper treatment formula. The process begins with excavation of the waste. Materials containing large pieces of debris must be prescreened. The waste is then placed into a high shear mixer (see photograph 5), along with premeasured quantities of water and SuperSet®, WASTECH's proprietary reagent.

Next, cementitious materials are added to the waste-reagent mixture, stabilizing the waste and completing the treatment process. WASTECH's treatment technology does not generate waste by-products. The process can also be applied in situ.



Photograph 5: WASTECH, Inc.'s solidification and stabilization technology

A field demonstration at Robins Air Force Base in Macon, Georgia was completed in August 1991. The WASTECH technology was used to treat high level organic and inorganic wastes at an industrial sludge pit. Preliminary results indicate that the organics and inorganics were immobilized by the technology, but the materials did not harden as they should. Additional applications will be necessary to verify cementing ability of the process. The technology is already being commercially applied to treat hazardous wastes contaminated with various organics, inorganics, and mixed wastes.

3. SITE Documents and Publications

The final products of each demonstration are generally two EPA reports; a Technology Evaluation Report (TER) and an Applications Analysis Report (AAR). The TER presents the results of the technology performance. It

describes the technology and its purpose, and presents the demonstration plan (including the operational plan, sampling and analysis procedures, QA/QC protocol, and health and safety issues), test results (with associated QA/QC data), and cost data. This lengthy and detailed publication is prepared by EPA, reviewed and approved by the developer, and distributed through the National Technical Information Service (NTIS). A project summary of the same material is printed and distributed by EPA to announce the report and to highlight the demonstration results.

The AAR discusses the applicability of the technology to other waste media, sites, constituents, and concentrations; it also details the capital and operating costs. EPA uses a common format for presenting cost information in all SITE reports. These costs include, but are not limited to, the following items: operating cost (including a list of requirements and the cost of each); maintenance cost; waste pre-

treatment and post-treatment costs, if applicable; and the potential for cost recovery (ability to recycle residues, or process streams, if applicable). This report includes a section for developer's comments, concerns, or additional technology claims. This section appears unedited in each AAR. Although EPA works with the developer throughout the demonstration process, including publication of the final reports, EPA maintains editorial control over the content of the reports, with the exception of the developer claims section of the AAR. Further, EPA conducts an independent evaluation of the developer's claims and supports claims made about the technology only to the extent that they are clearly proven by demonstration data or by other reliable and available data.

In addition to the above reports, demonstration results are also presented at technical conferences or published as technical papers in journals and symposium proceedings. These reports and papers provide EPA, the States, and the public with performance data on new commercial technologies with solutions to waste site problems, and with specific cost data useful for comparing and selecting on-site cleanup technologies. Other technology transfer items coming from a demonstration include the widely-distributed, two-page demonstration bulletin and a short videotape presentation of the demonstration and its results. Endorsements, approvals or certifications of any technology cannot be provided by EPA.

To date, EPA has published 14 AARs, 12 TERs and project summaries, and 7 demonstration bulletins. Articles and presentations of completed demonstrations also appear regularly in the Journal of the Air and Waste Management Association and at national and international meetings such as the Seventeenth Annual RREL Hazardous Waste Symposium, the Fifteenth Annual Army Environmental R & D Symposium, the First Engineering and Technology Conference on Waste Management, the Third Forum on Innovative Hazardous Waste Treatment

Technologies, and annual meetings of the Air and Waste Management Association and the American Institute of Chemical Engineers. Along with these technology-specific items, the Demonstration Program also produces the Annual Report to Congress, the Technology Profiles (summarizing the entire SITE Program), and a spring update of recent activities.

In an effort to continually improve the SITE Program, internal studies have suggested that the reporting process be streamlined as much as possible to facilitate timely transfer of information. To this end, the Demonstration Program has established the following schedule for producing reports following a field demonstration, with the end of the demonstration being day 0:

<u>Product</u>	<u>Days</u>
Draft Demonstration Bulletin	90
Draft AAR	135
Demonstration Bulletin Published	155
Draft TER	165
Videotape Available	250
AAR Published	349
TER and Project Summary Published	379

4. New Projects for FY 1991

During FY 1991, 23 new technologies were added to the SITE Demonstration Program. These were added through the annual Request for Proposals (6), the Emerging Technology Program (1), RREL technologies (5), nominations by EPA's regional offices and other federal agencies (4), and unsolicited proposals through telephone and conference contacts (7). These new technologies are briefly summarized below.

Accutech Remedial Systems, Inc. Keyport, NJ. An integrated treatment system incorporating Pneumatic Fracturing Extraction (PFE) and Catalytic Oxidation has been jointly developed by Accutech Remedial Systems Inc., and the Hazardous Substance Management Research Center located at the New Jersey Institute of Technology in Newark, New Jersey. The system provides a cost-effective accelerated remedial approach to sites with Dense Non-Aqueous Phase Liquid (DNAPL) contaminated aquifers. The patented PFE process has been demonstrated both in the laboratory and in the field to establish a uniform subsurface airflow within low permeability formations, such as clay and fractured rock. The PFE process coupled with an in situ thermal injection process recovers residual contamination trapped in the vadose zone. A groundwater recovery system is first implemented to suppress the water table below the zone of highest contamination. Recovered groundwater is treated by an aeration process. DNAPL contaminants removed from the groundwater are combined with the PFE recovery process stream. The combined DNAPL vapor stream is fed into a catalytic oxidation unit for destruction. The oxidation unit contains a catalyst that resists process deactivation. Heat from the catalytic/oxidation unit is utilized in the in situ thermal injection component of the treatment system. The treatment system can also use activated carbon treatment technology when contaminant concentrations decrease to levels where catalytic technology is no longer cost-effective.

Babcock and Wilcox Co. Alliance, OH. This furnace technology decontaminates wastes containing both organic and metal contaminants. The cyclone furnace retains heavy metals in a non-leachable slag and vaporizes and incinerates the organic materials in the wastes. The treated soils resemble natural obsidian (volcanic glass), similar to the final product from vitrification. The furnace is a horizontal cylinder and is designed for heat release rates greater than 450,000 British thermal units (Btu) per cubic

foot (coal) and gas temperatures exceeding 3,000°F. Natural gas and preheated primary combustion air (820°F) enter the furnace tangentially. Secondary air (820°F), natural gas, and the synthetic soil matrix (SSM) also enter tangentially along the cyclone barrel. The resulting swirling action efficiently mixes air and fuel and increases combustion gas residence time. Dry SSM has been tested at pilot-scale feed rates of both 50 and 200 pounds per hour (lb/hr). The SSM is retained on the furnace wall by centrifugal action; it melts and captures a portion of the heavy metals. The organics are destroyed in the molten slag layer. The slag exits the cyclone furnace (slag temperature at this location is 2,400°F) and is dropped into a water-filled slag tank where it solidifies into a nonleachable vitrified material. A small quantity of the soil also exits as fly ash from the furnace and is collected in a baghouse.

Chemical Waste Management, Inc. Geneva, IL. The PO*WW*ER™ technology treats wastewaters, such as leachates, groundwaters, and process waters, containing mixtures of salts, metals, and organic compounds. The proprietary technology combines evaporation and catalytic oxidation processes. Wastewater is concentrated in an evaporator by boiling off most of the water and the volatile contaminants, both organic and inorganic. Air or oxygen is added to the vapor, and the stream is forced through a catalyst bed, where the organic and inorganic compounds are oxidized. This stream, composed of mainly steam, passes through a scrubber, if necessary, to remove any acid gases formed during oxidation. The stream is then condensed or vented to the atmosphere. The resulting brine solution is either disposed of or treated further, depending on the nature of the waste.

Dames and Moore. Tallahassee, FL. Dames & Moore developed its Hydrolytic Terrestrial Dissipation (HTD) process for use at the Chemairspray site in Palm Beach County, Florida. An estimated 11,500 cubic yards of surface soils at the site are contaminated with

toxaphene -- a chlorinated pesticide -- and metal fungicides, primarily copper. HTD involves excavating contaminated soils and comminuting (mixing and cutting) soils so that metal complexes and organic chemicals in the soil are uniformly distributed. During the mixing process, caustic addition raises the soil pH to 8.0 or greater, although slower reactions should still occur at lower pHs. Soil moisture levels are maintained during mixing to prevent adsorption and fugitive dust. Iron, copper, or aluminum can be introduced to catalyze the hydrolysis. The prepared mixture is then distributed in a thin veneer (4 to 7 centimeters) over a soil bed and exposed to heat and ultraviolet light from the sun to facilitate dissipation. Since lighter weight toxaphene compounds are reported to be volatile, volatility will enhance dissipation. Toxaphene's volatility will increase as heavier compounds are dehalogenated to lower molecular weights. Ultraviolet light is also known to cause toxaphene dechlorination, so toxaphene gases in the atmosphere will slowly degrade to still lower molecular weights while liberating chlorine. Since lighter compounds have fewer chlorines in their molecular structure, only minor amounts of chlorine gas are emitted to the atmosphere. Soils in the distribution bed are periodically sampled to evaluate any residual contamination. One staging unit can treat about 5,000 to 6,000 tons per year.

Dynaphore, Inc. Richmond, VA. The FORAGER™ sponge is an open-celled cellulose sponge incorporating an amine-containing polymer with a selective affinity for heavy metals in cationic and anionic states in aqueous solution. The polymer prefers to form complexes with ions of transition-group heavy metals, providing ligand sites that surround the metal and form a coordination complex. The order of affinity of the polymer for metals is influenced by solution parameters such as pH, temperature, and total ionic content. The removal efficiency for transition-group heavy metals is about 90 percent at a flow rate of one bed volume per minute. The highly porous

nature of the sponge speeds diffusional effects, thereby promoting high rates of ion absorption. The sponge can be used in columns, fishnet-type enclosures, or rotating drums. In column operations, flow rates of three bed volumes per minute can be obtained at hydrostatic pressures only 2 feet above the bed, without additional pressurization. Therefore, sponge-packed columns are suitable for unattended field use.

ECOVA Corporation. Redmond WA. ECOVA Corporation's slurry-phase bioremediation (bioslurry) technology is described in the section for completed demonstration projects.

ELI Eco Logic International, Inc. Rockwood, Ontario, Canada. This patented process is based on the gas-phase, thermo-chemical reaction of hydrogen with organic and chlorinated organic compounds at elevated temperatures. At 850 degrees Celsius (°C) or higher, hydrogen reacts with organic compounds in a process known as reduction to produce smaller, lighter hydrocarbons. This reaction is enhanced by the presence of water, which can also act as a reducing agent. Because hydrogen is used to produce a reducing atmosphere devoid of free oxygen, the possibility of dioxin or furan formation is eliminated. The thermo-chemical reaction takes place within a specially designed reactor. In the process, a mixture of preheated waste and hydrogen is injected through nozzles mounted tangentially near the top of the reactor. The mixture swirls around a central ceramic tube past glo-bar heaters. By the time the mixture passes through the ports at the bottom of the ceramic tube, it has been heated to 850°C. Particulate matter up to 5 millimeters in diameter not entrained in the gas stream will impact the hot refractory walls of the reactor. Organic matter associated with the particulate is volatilized, and the particulate exits out of the reactor bottom to a quench tank, while finer particulate entrained in the gas stream flows up the ceramic tube into an exit elbow and through a retention zone. The reduction reaction takes

place from the bottom of the ceramic tube onwards, and takes less than one second to complete. Gases enter a scrubber where hydrogen chloride fine particulates are removed. The gases that exit the scrubber consist only of excess hydrogen, methane, and a small amount of water vapor. About 95 percent of this gas is recirculated into the reactor. The remaining 5 percent is fed to a boiler where it is used as supplementary fuel to preheat the waste.

Ensate, Inc. Tucker, GA. The SafeSoil™ Biotreatment System is a bioremediation technology that involves excavation and power screening of contaminated soil. The screened soil is then transported to a paddle shaft mixer, where it is mixed with a combination of nutrients and surfactants. The mixed soil is then placed in "curing" piles on site for the curing portion of the treatment process, in which biodegradation by naturally occurring microorganisms, utilizing biochemical pathways mediated by enzymes, occurs. All required nutrients are supplied during initial processing. The unique air entrainment feature of the treatment system provides an initial supply of oxygen and provides for passive air diffusion, by the generation of a honeycomb-like matrix. The process relies solely on indigenous microorganisms of the soil to biologically degrade organic compounds; it does not use laboratory adapted or genetically engineered microorganisms (GEMs).

Hazardous Waste Control. Fairfield, CT. The NOMIX® technology is a patented solidification and stabilization process that can be applied to contaminated media in situ, without the need for mixing or equipment. The technology combines specially formulated cementitious materials with waste media. Because the material hardens faster than conventional concrete, remediation time is reduced. The NOMIX® solidification compounds consist of specially formulated cements, sands, aggregates, and various combinations thereof. The dry components and their reacting rates with the wet waste are

closely controlled, allowing rapid and efficient solidification. The contaminated media may be diluted with water, if necessary, to facilitate the solidification process. If water is necessary, it may be introduced into the waste media before the preblended solidification compounds are added create a homogenous solution of waste and water. The solidification compounds are then poured through the waste and water solution in a consistent manner, allowing the complete absorption of the waste solution and the formation of a solid mass. The process produces a relatively homogenous treated mass compared to that produced by solidification processes using mixing equipment.

Hughes Environmental Systems, Inc. Manhattan Beach, CA. The steam injection and vacuum extraction (SIVE) process, developed by Hughes Environmental Systems, is described in the section for completed demonstration projects.

MAECORP, Inc. Chicago, IL. MAECORP, Inc.'s MAECTITE process is a chemical fixation treatment technology that reduces leachable lead levels in soils. The treatment process has several steps. First the soil material is screened so that oversized particles larger than approximately 3 inches are removed from the waste stream. The remaining undersized particles are blended with a trademarked material and then fed to a shredder/grinder. This material is then conveyed to a pug-mill mixer where a liquid solution is added. This mixture is then fed to a pad and cured for 6 to 24 hours, after which time it can be land disposed.

Peroxidation Systems, Inc. Tucson, AZ. The perox-pure™ technology destroys dissolved organic contaminants in groundwater or wastewater through an advanced chemical oxidation process using ultraviolet (UV) radiation and hydrogen peroxide. Hydrogen peroxide is added to the contaminated water, and the mixture is then fed into the treatment system. The treatment system contains four or

more compartments in the oxidation chamber. Each compartment contains one high intensity UV lamp mounted in a quartz sleeve. The contaminated water flows in the space between the chamber wall and the quartz tube in which each UV lamp is mounted. UV light catalyzes the chemical oxidation of the organic contaminants in water by its combined effect upon the organics and its reaction with hydrogen peroxide. First, many organic contaminants that absorb UV light may undergo a change in their chemical structure or may become more reactive with chemical oxidants. Second, and more importantly, UV light catalyzes the breakdown of hydrogen peroxide to produce hydroxyl radicals, which are powerful chemical oxidants. Hydroxyl radicals react with organic contaminants, destroying them and producing harmless by-products, such as carbon dioxide, halides, and water. The process produces no hazardous by-products or air emissions.

Purus, Inc. San Jose, CA. This technology destroys organic contaminants dissolved in water through an advanced chemical oxidation process using ultraviolet (UV) radiation, hydrogen peroxide, and a proprietary catalyst. Contaminated water is fed into the system, and hydrogen peroxide and the proprietary catalyst are added. The mixture is then pumped to the treatment system, which consists of six reactor tanks where the organic contaminants are destroyed. Each reactor tank houses a xenon UV lamp mounted in a quartz sleeve. The water flows in the space between the chamber wall and the quartz tube in which each lamp is mounted. The UV lamps serve two purposes. First, the combination of UV light and hydrogen peroxide produces hydroxyl radicals, which are powerful chemical oxidants. The hydroxyl radicals oxidize organic contaminants, producing harmless by-products, such as carbon dioxide, salts, and water. Second, the UV light can directly break the molecular bonds of the contaminants, further enhancing the oxidation process.

Remediation Technologies, Inc. Pittsburgh, PA. Remediation Technologies, Inc.'s (ReTeC), high temperature thermal processor is a thermal desorption system that can treat solids and sludges contaminated with organic constituents. The system consists of material feed equipment, a thermal processor, a particulate removal system, an indirect condensing system, and activated carbon beds. Waste from the feed hopper is fed to the thermal processor, which consists of a jacketed trough that houses two intermeshing, counter-rotational screw conveyors. The rotation of the screws moves material through the processor. A molten salt eutectic, consisting primarily of potassium nitrate, serves as the heat transfer media. This salt melt has heat transfer characteristics similar to those of oils and allows maximum processing temperatures of up to 850°F. The salt melt is noncombustible; it poses no risk of explosion; and its potential vapors are nontoxic. The heated transfer media continuously circulates through the hollow flights and shafts of each screw and circulates through the jacketed trough. An electric or fuel oil/gas-fired heater maintains the temperature of the transfer media. Treated product is cooled to less than 150°F for safe handling.

Risk Reduction Engineering Laboratory, U.S. EPA. Cincinnati, OH. The base-catalyzed dechlorination (BCD) process was developed by the Risk Reduction Engineering Laboratory (RREL) in Cincinnati, Ohio. This process uses no polyethylene glycol (PEG) and is a clean and inexpensive process for remediating soils and sediments contaminated with chlorinated organic compounds. The process begins by mixing the chemicals with the contaminated matrix, such as excavated soil or sediment or liquids containing toxic compounds. This mixture is heated at 340 degrees Celsius (°C) for several hours. The off-gases are treated before they are released into the atmosphere. The treated remains are nonhazardous and can be either disposed according to standard methods or further processed for separating components for reuse.

Demonstration of the technology is planned in conjunction with the Navy.

Risk Reduction Engineering Laboratory, U.S. EPA, Cincinnati, OH. This biological treatment system uses the injection of atmospheric air to treat contaminated soil in situ. This air provides a continuous oxygen source, which enhances the growth of microorganisms naturally present in the soil. The system uses a low-pressure air pump attached to one of a series of air injection probes. The air pump operates at extremely low pressures, allowing inflow of oxygen without volatilizing contaminants that may be present in the soil. The treatment capacity is limited by the number of injection probes, the size of the air pump, and site characteristics such as soil porosity. Aerobic microbial growth in contaminated soil is often limited by the lack of oxygen. Additional additives, such as ozone or nutrients, also may be required to stimulate microbial growth.

Risk Reduction Engineering Laboratory, U.S. EPA, Cincinnati, OH. This technology has been developed for EPA's Risk Reduction Engineering Laboratory by the University of Cincinnati (UC) at the Center Hill facility. Hydraulic fracturing is a physical process that creates fractures in soils to enhance fluid or vapor flow in the subsurface. The technology places fractures at discrete depths through hydraulic pressurization at the base of a borehole. These fractures are placed at specific locations and depths to increase the effectiveness of treatment technologies, such as soil vapor extraction, in situ bioremediation, and pump-and-treat systems. The technology is designed to enhance remediation in low permeability geologic formations.

The fracturing process begins with the injection of a fluid (water) into a sealed borehole until the pressure of the fluid exceeds a critical value and a fracture is nucleated, forming a starter notch. A proppant composed of a granular material (sand) and a viscous fluid (guar gum and water mixture) is then pumped

into the fracture as the fracture grows away from the well. After pumping, the proppant grains hold the fracture open while an enzyme additive breaks down the viscous fluid. The resulting fluid is pumped from the fracture, forming a permeable subsurface channel suitable for delivery or recovery of a vapor or liquid.

Risk Reduction Engineering Laboratory, U.S. EPA, Cincinnati, OH. The fungal degradation project is described in the section for completed field demonstrations.

Rochem Separation Systems, Inc. Torrance, CA. This technology uses membrane separation systems to treat a range of aqueous solutions from seawater to leachates containing organic solvents. The system uses osmosis through a semipermeable membrane to separate pure water from contaminated liquids. The application of osmotic theory implies that when a saline solution is separated from pure water by a semipermeable membrane, the higher osmotic pressure of the salt solution (due to its higher salt concentration) will cause the water (and other compounds having high diffusion rates through the selected membrane) to diffuse through the membrane into the salt water. Water will continue to permeate into the salt solution until the osmotic pressure of the salt solution equals the osmotic pressure of the pure water. At this point, the salt concentrations of the two solutions will be equal, after which no driving force will remain for any additional mass transfer across the membrane. However, if an external pressure is exerted on the salt solution, water will flow in the reverse direction from the salt solution into the pure water. This phenomenon, known as reverse osmosis (RO), can be employed to separate pure water from contaminated matrices, such as the treatment of hazardous wastes via concentration of hazardous chemical constituents in an aqueous brine, while recovering pure water on the other side of the membrane.

Ultrafiltration (UF) is a pressure-driven, membrane filtration process that separates and

concentrates macromolecules and colloids from process streams, water and wastewaters. The size of the particle rejected by ultrafiltration depends on the inherent properties of the specific membrane selected for separation and can range from small particulate matter to large molecules. In general, a fluid is placed under pressure on one side of a perforated membrane having a measured pore size. All materials smaller than the pore pass through membrane, leaving larger contaminants concentrated on the feed side of the process. Pass-through constituents can be controlled by using a membrane with a limiting pore size, or by installing a series of membranes with successively smaller pores. Although similar to RO, the UF process typically cannot separate constituents from water to the purity that RO can. Therefore, the two technologies can be used in tandem, with UF removing most of the relatively large constituents of a process stream before RO application selectively removes the water from the remaining mixture.

SoilTech, Inc. Englewood, CO. SoilTech, Inc.'s Anaerobic Thermal Processor is described in the section for completed demonstration projects.

Terra-Kleen Corporation. Oklahoma City, OK. The soil restoration unit is a mobile solvent extraction remediation device for the on-site removal of organic contaminants from soil. Soil contaminants are extracted with a mixture of organic solvents in a closed loop, countercurrent process that recycles all solvents. Terra-Kleen Corporation uses a combination of up to 14 solvents, each of which can dissolve specific contaminants in the soil and can mix freely with water. None of the solvents is a listed hazardous waste, and the most commonly used solvents are approved by the Food and Drug Administration as food additives for human consumption. The solvents are typically heated to efficiently strip the contaminants from the soil. Contaminated soil is fed into a hopper and transported into the soil and solvent slurry modules. In the modules, the soil is continually leached by clean solvent. The return leachate

from the modules is monitored for contaminants so that the soil may be retained within the system until any residual contaminants within the soil are reduced to targeted levels. Terra-Kleen Corporation offers "hotspot protection" in which real-time monitoring of the contaminant levels alleviates the problems of treating localized higher contaminant areas of soil.

Texaco Syngas, Inc. White Plains, NY. The Texaco entrained-bed gasification process is a noncatalytic partial oxidation process in which carbonaceous substances react at elevated temperatures to produce a gas containing mainly carbon monoxide and hydrogen. This product, called synthesis gas, can be used (1) to produce other chemicals or (2) to be burned as fuel. Ash in the feed melts and is removed as a glass-like slag. The treatment of hazardous waste materials in a gasifier is an extension of Texaco's conventional gasification technology, which has been operated commercially for over 30 years using widely varying feedstocks, such as natural gas, heavy oil, coal, and petroleum coke. The process treats waste material at pressures above 20 atmospheres and temperatures between 2,200 and 2,800°F.

Texarome, Inc. Leakey, TX. This solid waste desorption process uses superheated steam (up to 900°F) as a continuous conveying and stripping gas in a pneumatic system to treat contaminated solids. The countercurrent flow of the gas (steam) and the solid phase (contaminated solids) provides a highly compact and efficient mass transfer separation. While the word pneumatic typically refers to air as a carrier gas, the carrier gas in this case is superheated steam, which is quite suitable for pneumatic conveying. However, unlike air at ambient temperatures, superheated steam as a carrier gas vaporizes the volatile and semivolatile substances present in the solids. The system uses a proprietary piping arrangement within the conveying system, which allows for a true countercurrent flow and a multistage dispersion and separation (desorption) of the gases from the solids. This makes the

efficient mass transfer task possible. After desorption of virtually all volatile substances from the solid substrate, the last stage of the apparatus is used for quenching and as a reactor loop to provide a final chemical breakdown of the minute traces of volatiles left in the solid, if necessary. Nonvolatile inorganic contaminants (such as metals) are not separated but do not inhibit the process.

Weston Services, Inc. West Chester, PA.

The basis of the LT³® technology is the thermal processor, an indirect heat exchanger used to dry and heat contaminated soils. The LT³® process includes three main steps: soil treatment, emissions control, and water treatment. Excavated soil is processed through a shredder to increase the surface area of the soil. (This step may not be needed for sludges or similar matrices.) The conveyor and surge hopper, which are enclosed to reduce emissions, then feed the soil into the thermal processor. The thermal processor consists of two covered troughs that house four intermeshed screw conveyors. The covered troughs and screws are hollow to allow circulation of hot oil, providing indirect heating of the soils. Each screw moves the soil through the processor and thoroughly mixes the material. Heating of the soil to 400 to 500°F evaporates contaminants from the soil. (Temperatures may vary depending on the specific contaminants of concern.) The vapor stream is then processed through a baghouse dust collector, and two condensers in series. It is then treated by carbon adsorption to remove about 99 percent of the organic contaminants and any particulate emissions. The remaining exhaust gas is continuously monitored to ensure that it contains total organic concentrations not greater than 3 parts per million (ppm) by volume.

5. Future Needs and Direction

Each January, EPA advertises a solicitation for projects in the *Commerce Business Daily* to identify new processes for the Demonstration

Program. EPA then evaluates developer proposals in response to this solicitation for selection into the SITE Demonstration Program by early summer. This system has been in effect for the life of the program and will continue as a base for accepting technologies for demonstration.

During FY 1991, however, more technologies entered the program through proposals outside the solicitation timeframe, or from regional or RREL nominations, than through the regular solicitation process. Several excellent technologies were brought into the program as a direct result of staff interaction. The RFP will continue to be the cornerstone for the program since it sets the guidelines for proposal evaluation and technologies of interest, but in the future, additional recruiting will be done through the regional offices and technical forums, as recommended in the 1990 Management Study of the SITE Program. Developers who have already arranged with an EPA regional office or a private client for a treatability study or field demonstration are good candidates for acceptance into the Demonstration Program since the site selection and preliminary planning steps may be bypassed. Projects such as this are usually referred to as fast-track projects, and all attempts are made to fit a technology demonstration into the schedule and plan that has already been developed independently.

The RFP planned for FY 1992 will highlight technology needs in the following areas:

1. Combinations of unit operations to create treatment trains for specific wastes and waste site conditions.
2. Treatment of mixed, low level radioactive waste in soils and groundwater. Mixed waste treatment technologies may be demonstrated at DOE sites.

3. Source control technologies for soil and sludge capable of treating organic and inorganic contaminants to keep them from groundwater contact rather than treating contaminated water.
4. Material handling techniques which improve pre-treatment and post-treatment operations.
5. In situ and on-site treatment processes for large volumes of soil and sediment with relatively low contaminant concentration levels.

Methods for material handling noted in item 4 above may include shredding, crushing, sorting, extracting or separating hazardous materials. Technologies for on-site aqueous treatment and gas treatment may also be proposed, but are anticipated to be of lower priority to the program. Specific soil pollutants identified by EPA's regional offices as needing technologies for remediation will include lead, arsenic, PCP, polynuclear aromatic (PNA) compounds, and dioxins.

The RFP will further attempt to guide developers in proposal writing by defining two or three representative sites of interest to the SITE Program's clients. Military sites, chemical manufacturing sites, and abandoned impoundments are among the types of problem areas that may be specifically noted.

Another major source of demonstration projects that is just beginning to open up is the Emerging Technology Program. As technologies move through this two-year program, it is hoped that they develop into field-ready processes for demonstration and evaluation. One emerging technology process was invited to participate in a demonstration during FY 1991, and it is anticipated that this number will grow substantially in the future.

As the Program has matured over the past six years, it has become apparent that a

tremendous amount of flexibility is necessary in order to respond to the mandate of increasing this country's base of viable cleanup technologies. Encouraging fast-track projects, combining demonstrations with ongoing Superfund remediation efforts (mainstreaming), linking demonstrations with technical assistance activities, and cooperating with other agencies such as the Department of Defense and the Department of Energy is helping to increase the number and scope of demonstrations. These efforts, along with a concerted drive to maintain the reporting schedule outlined previously, will significantly increase the impact of the SITE Demonstration Program on Superfund cleanup operations.

B. EMERGING TECHNOLOGY PROGRAM

The Emerging Technology Program (ETP) fosters the development of innovative treatment technologies either at a bench-, pilot-, or field-pilot scale level. The goal of the ET program is to ensure that a steady stream of permanent, cost effective hazardous waste treatment technologies are available for field demonstration, thereby increasing the number of viable treatment technologies available for use at hazardous waste sites.

Selection and Funding

Each year since 1987, between May and June, EPA announces in the *Commerce Business Daily* and trade journals the intent to issue a Request for Preproposals (RFP). A preproposal is a condensed proposal of 10 pages, which is used for initial evaluation and screening. Interested technology developers are invited to request an RFP, which describes and specifies how to submit the preproposal. The developer must address basic evaluation criteria, called selection factors. Selection factors for the recent E05 (1991) solicitation are as follows:

Technical Description of Treatment Technology; Description of the Proposed Development Project Plan; Summary of Data and Results to Date; Estimated Resources (Funding) Needed for the Proposed Project (including developer's Share); Value of the Technology to Superfund; Company and Personnel Background and Experience; and Company Capability to Commercialize the Technology.

In July, the RFP is sent to all parties who responded to the announcement. The RFP is intended to solicit innovative technologies from the private sector, universities, and/or government agencies for further testing and development. These technologies must show promise in solving the most pressing problems at Superfund sites.

Preproposals are evaluated by a panel of experts from both within and outside EPA. Preproposals are initially scored based on established selection factors. If the scores are high and the technology shows promise in meeting Superfund's needs, the developer will be invited to submit a detailed Cooperative Agreement Application for funding consideration. The number of selected technologies invited to submit a Cooperative Agreement Application may be influenced by available funding for that fiscal year. Based on the technical quality of the application as established by both internal and external reviewers and the cost sharing proposed by the applicant, EPA awards successful applicants up to \$150,000 a year for a maximum of two years, subject to the funding restrictions in CERCLA Section 311(b)(5)(J). Before approving second year funding, EPA reviews the project to determine that sufficient progress was made during the first year to warrant additional funding. The EPA envisions that preliminary results will be available by the end of the first year to assist in making this decision.

Time required for issuance of the RFP, receipt of preproposals, technical review by internal and external reviewers, evaluation and

selection of preproposals, and the invitation to submit Cooperative Agreement Applications is approximately 5 months. Receipt of the Cooperative Agreement Application, technical review and evaluation of the application, and final award of financial assistance under the Cooperative Agreement takes an additional 5 to 6 months.

1. Project Management

The EPA manages the projects through an experienced project officer who provides technical and administrative support and guidance to the recipients and ensures that the projects continue in a direction which will provide reliable data and further progress. The EPA project officer ensures that the project conforms with the program goals and directs the project through both verbal and written instructions, and with direct contact via visits to the recipient's research facility. At the conclusion of the project, EPA will review the final project report, and after required revisions, publish project results. Promising technologies may be invited to participate in the Demonstration Program.

Innovative technologies selected for the ETP are funded and managed as EPA Cooperative Agreements. Rules and regulations for Cooperative Agreements are described in 40 CFR Part 30. Particular points to note are described below.

Recipients of awards under this program must provide a portion of the costs for conducting the projects. Although a specific amount of 5 percent cost sharing is required, generally, applicants offer to cost share in excess of 30 percent. The EPA views cost sharing by the applicant as an indication of the applicant's commitment to and confidence in the proposed technology. The applicant also usually provides equipment, facilities, applicable wastes (spiked simulated wastes), and disposal of residues. The

Table 1 - Summary of Emerging Technology Program Solicitations

Solicitation	Date	Number of Preproposals Submitted	Number of Proposals Submitted	Number of Projects Selected
E01	November 1987	80	15	7
E02	July 1988	60	17	7
E03	July 1989	47	18	17
E04	July 1990	74	20	13
E05	July 1991	66	13	*

* E05 projects selection in March 1992

applicant is responsible for complying with all federal, state, and local regulations regarding procurement, storage, testing and disposal of hazardous or toxic wastes. The applicant must also agree to comply with EPA quality assurance/quality control (QA/QC) requirements covering such items as sampling methods, analytical techniques, spikes, replicates, blanks and the preparation of a Quality Assurance Project Plan for EPA review and approval prior to starting the study. The recipient must also provide EPA with Quarterly Project reports (not published), an interim report and an acceptable final report suitable for publication in accordance with EPA guidelines.

2. Emerging Technology Trends

The ETP shows trends in the types of technologies being developed, illustrating needs and interest for future application. The program began with funding for seven projects. Interest in the ETP and dollars made available by the Department of Energy, the Department of

Defense, and the Air Force, allowed growth in 1990 and 1991.

High interest in the program is demonstrated by the number of preproposals submitted each year. The ETP has averaged annually a total of 65 preproposals from 1987 through the 1991 solicitation (Table I).

From these preproposals, technologies selected in each category by year, are as follows: 1987, Biological (2), Chemical (3), Physical (2); 1988, Chemical (1), Physical (4), Material Handling (1), Thermal (1); 1989, Biological (5), Chemical (5), Material Handling (2), Thermal (3), Physical (1), Solidification/Stabilization (1); and 1990, Biological (3), Physical (3), and Chemical (2), Thermal (3), Solidification/Stabilization (1), Material Handling (1). 1991 Cooperative Agreement Applications are currently being reviewed. Current projects total 44 and break down as follows: Solidification/Stabilization (2), Material Handling (4), Thermal (7), Biological (10), Physical (10), and Chemical (11) (see Figure 2).

The majority of technologies are physical, chemical or biological. Treatment usually involves soils, sludges, and liquids with less emphasis on air. However, destruction of organics in the air phase is currently being researched. Emphasis on soils, sediments and sludges was initiated in previous RFPs and response has been favorable.

The EPA is primarily interested in those technologies that can handle complex mixtures of hazardous organic and inorganic contaminants (including radioactive wastes) or provide improved solids handling and/or pretreatment. Some of the treatment technologies of particular interest are 1) in situ treatment processes, 2) combinations of unit operations to create treatment trains, and 3) material handling techniques which improve pre- and post-treatment operations.

Some technologies and recipient organizations in the ETP have received Agency and other awards. To date, seven ET projects have been completed; five have been invited into the Demonstration Program. Additional information is available in *The Superfund Innovative Technology Evaluation Program: Technology Profiles Fourth Edition (EPA/540/5-91/008)*.

A number of technologies in the ETP are at the pilot-scale level, with several being implemented as field research efforts. Technologies accepted into the program generally are further developed than the first bench-scale stage, as it is more beneficial to the Superfund program to assist developers with technologies that have a greater promise of moving into the Demonstration Program and commercializing the technology for hazardous waste site remediation.

The ETP 1) stimulates a greater interest from the private sector for development of innovative technologies, 2) attracts a variety of innovative technologies not yet commercially available, 3) supplies technologies to the

Demonstration Program, and 4) provides processes ready for field pilot-scale testing.

3. 1991 Selected Emerging Technologies

A brief summary of the 13 new technologies accepted into the ET program from the 1990 solicitation are described in the following paragraphs. All six technology categories are represented in these brief summaries. Each technology is listed in alphabetical order by the developer's company and location, followed by the title of the project.

Center for Hazardous Materials Research. Pittsburgh, PA. Secondary Lead Smelters for the Recovery of Lead from Waste Lead-Acid Battery Casings. The Center for Hazardous Materials Research will use secondary lead smelting technology to reclaim lead from waste materials such as lead contaminated rubber battery casings, slags, and other wastes containing lower concentrations of lead (in the range of 1 to 10%) as compared to current feedstock which typically contains 30 to 65% lead. The net result will be the detoxification of these materials, while providing a viable product (i.e., reclaimed lead).

This technology involves the use of furnaces which heat a mixture of lead and other materials and remove the lead via a combination of melting and reduction. The technology is based on existing reverberatory furnace design and basic pyrometallurgy. Feed materials are sized and screened to remove large debris. Next, grinding and crushing equipment reduce the size of the feed material, which is then charged to the gas fired reverberatory furnace. The reverberatory furnace essentially operates as a melting furnace. The pure metallic lead portion of the feedstock (as opposed to any oxide content) is melted to produce molten lead which accumulates and is removed periodically from the bottom of the furnace. The reverberatory furnace's operating conditions

(relatively lower temperatures, short detention time, and oxidizing atmosphere as compared to a blast furnace) cause any metal (lead) oxide portion of the feedstock to report to the furnace's slag waste stream, and is therefore not recovered in the reverberatory furnace.

The high temperature, long detention time, and reducing conditions of the blast furnace, on the other hand, serve the function of 1) melting of metallic lead, and 2) metallurgical reduction of lead oxides to produce pure molten lead. Slag waste from the reverberatory furnace, and other waste streams which contain lead (predominantly in the lead oxide form), are charged into a natural gas fired blast furnace along with coke, iron (a slag conditioner) and lime. The furnace operates at 2200-2400°F. Molten lead is removed from the furnace, further purified and refined, and reclaimed for reuse in the production of new lead-acid batteries.

Davy Research and Development, Ltd. Cleveland, England. **Resin In-Pulp and Carbon In-Pulp Technology for Contaminated Land Treatment.** The leach Resin-In-Pulp (RIP) and Carbon-in-Pulp (CIP) technologies developed by Davy Research & Development Ltd., are based on the extraction, adsorption, and removal of organics and inorganics from the slurry phase of a soil-water extractant mixture.

Presently, the RIP/CIP technology is used for the recovery of metals from ores. The RIP technology is well established in the recovery of uranium, where anion exchange resins are used to adsorb the uranium which is leached as uranyl anion. The CIP process is commonly used to adsorb gold and silver which are leached as cyanide complexes. Both RIP and CIP technologies are carried out in multistage continuous countercurrent contactors in horizontal arrangement. The incoming contaminated material is either passed to wet screens or is subject to tramp (debris) removal and crushing before reaching the wet screens. Fine material passing the wet screen is sent to

the agitated leach tank where the contaminants are extracted. The coarse material is sent to a vat leach/washing stage or returned to the crushing step. The leached fines and the vat leach liquor are combined and treated with cyclones to separate the sands from the clays. When the material contamination exceeds 10,000-25,000 mg/kg soil, soil-liquid separation is used before the cyclone stage with the liquid passing directly to precipitation/disposal and the fine solids being reslurried before passing to the cyclone. The clays and leach liquor then pass to the RIP or CIP contactor where the contaminants are adsorbed onto ion exchange resins or activated carbons. The thickened, treated solids are collected from the thickener and the vat leach/washing step for disposal or post-treatment. The resin/carbons are regenerated and recycled with the concentrated contaminants being subjected to further treatment, disposal, or recovery.

Groundwater Technology Government Services, Inc. Concord, CA. Bioremediation in In-Situ Reactors. Bioremediation is a proven technique for the remediation of soils containing a variety of organic compounds. The Groundwater Technology Government Services (GTGS) technology involves stimulating the indigenous microbial population to degrade cyclodiene insecticides, such as chlordane and heptachlor. The goal of bioremediation is to convert organic wastes into biomass and harmless by-products of microbial metabolism such as carbon dioxide, water, and inorganic salts. The GTGS technology relies on aerobic metabolism of microorganisms present at the site.

In the GTGS technology, contaminated soils are excavated and the site is lined with an impermeable layer. The liner is used to protect against any possible groundwater contamination during operation of the bioremediation system. A leachate collection system is installed to avoid saturated conditions at the site. The excavated soil is conditioned using shredding/sieving equipment, and bulking agents are added to

assist in supplying oxygen for aerobic degradation. A negative pressure vacuum extraction system will control and capture any volatile organic compounds released during operation.

Institute of Gas Technology (IGT). Chicago, IL. **Integrated Chemical and Biological Treatment.** IGT's Chemical-Biological Treatment (CBT) process remediates sludges and soils contaminated with organopollutants. This process will not be adversely affected by radionuclides or heavy metals. The treatment system combines two remedial techniques: 1) chemical oxidative pretreatment using a chemical reagent and 2) biological treatment using aerobic and/or anaerobic biosystems either in sequence or alone, depending on the waste.

In the reagent reactions, metal salts and hydrogen peroxide combine to produce the hydroxyl radical, a powerful oxidizer. The reaction of the hydroxyl radical with organic contaminants causes chain reactions, resulting in modification and degradation of organics to biodegradable and/or environmentally benign products. These products are later destroyed in the biological step.

Wet oxidation and ozone (O_3) are other commonly used chemical oxidation techniques which will be evaluated and compared to IGT's chemical treatment. Wet oxidation is a thermal treatment in which a slurry consisting of water and a carbonaceous material is heated to temperatures in the range of 250°F to 650°F and under pressure of air or oxygen. If sufficient oxygen is present the carbonaceous material can be oxidized completely to CO_2 and water. Under a limited oxygen condition, the organic compounds are oxidized or modified for subsequent biodegradation. The CBT technology will use wet oxidation with or without chemical treatment or ozonation for pretreatment of contaminated soils.

In the second stage of the CBT technology, biological systems are used to degrade the hazardous residual materials as well as the partially oxidized material from the first stage. Chemically treated wastes are subject to cycles of aerobic and anaerobic degradation if aerobic or anaerobic treatment alone is not sufficient.

International Technologies Corporation. Knoxville, TN. **Treatment of Mixed Waste Contaminated Soil.** The objective of this mixed waste treatment technology is to decontaminate soils and separate the hazardous components from soils into distinct organic and inorganic phases. The separated streams can then be further minimized, recycled, destroyed and/or disposed of at permitted disposal facilities. The decontaminated soil can be safely returned to the site and the clean wash water can be reused or discharged.

The process utilizes thermal separation, gravity separation, water treatment, and chelant extraction to address the various elements in the waste feed stream. Organics are removed intact by thermal separation while radionuclides and heavy metals are removed by physical/chemical separation techniques. The process is expected to run semi-continuously at the pilot scale.

The initial treatment step is to prepare the bulk contaminated soil for processing by physical separation and crushing/grinding. Volatile and semivolatile organics are separated as a distinct organic condensate phase by low temperature thermal treatment. The contaminated aqueous condensate is treated to remove/destroy soluble organics and the aqueous phase is returned for reuse.

After feed conditioning, the inorganically contaminated soils are directed to gravity concentrating devices for separation of clean from contaminated soil. The contaminated wash water stream from the gravity separation process is treated using a potassium ferrate based chemical formulation to remove the soluble and

suspended radionuclides and heavy metals and return the clean water for reuse.

Gravimetrically separated soils which are still contaminated with the more difficult chemically bonded radionuclides are further treated with the chelant extraction process. The majority of the chelant/radionuclide phase is separated from the soil matrix and the solution passes through ion exchange resin beds to isolate the radioactivity and allow for recycle of the chelant. The contaminants are collected as concentrates from all waste process streams for recovery of off-site disposal at commercial hazardous waste and radiological waste facilities, and the decontaminated soil is then returned to the site as clean fill.

New Jersey Institute of Technology (NJIT). Newark, NJ. Integrated Pneumatic Fracturing Bioremediation. NJIT integrates two innovative techniques, pneumatic fracturing and bioremediation, to enhance in situ remediation of soils contaminated with petroleum hydrocarbon, benzene, toluene and xylene.

The system will employ pneumatic fracturing to enhance stacked aerobic, denitrifying and methanogenic microbial processes, in staggered spatial distribution for maximum effectiveness. Aerobic processes will dominate at the fracture interfaces and, to a limited distance, into the soil away from the fracture. Depletion of oxygen during aerobic biodegradation allows the formation of a denitrifying zone a short distance away from the fracture. Nitrate is depleted by denitrifying at greater distances away from the fractures. Contaminant diffusion processes will be towards the fracture, serving as substrate for various microbial populations. This stacking arrangement results in enhanced growth of the aerobic population through reduction in substrate concentrations in the denitrifying and methanogenic zones.

The pneumatic fracturing process consists of injecting high pressure air or other gas into soil formations at controlled flow rates and pressures. In low permeability soils, the process creates conductive channels in the formation. This increases the permeability and the exposed surface area of the soil, thereby accelerating removal and/or treatment of the contaminants. In high permeability soils, the process provides a means for rapidly aerating the soil formation.

Methanogenic degradation of organic compounds is a microbial fermentation process which depends on a consortia of three groups of bacteria. The acidogens, non-methanogenic chemoheterotrophs, oxidize complex organic compounds to short chain volatile fatty acids. Acetogenic bacteria reduce the fatty acids to acetate, carbon dioxide, and hydrogen. Methanogens can then reduce the carbon dioxide to methane. The methanogens are also capable of producing methane from acetates, formate, methanol and methylated amines.

Nutech Environmental Co. London, Ontario, Canada. Technology for Destruction of Organics and Inorganics in Aqueous Streams. The Nutech photocatalytic oxidation process utilizes illuminated TiO_2 in the presence of ozone and/or hydrogen peroxide for destruction of organic pollutants and detoxification of inorganic pollutants in water streams.

The illumination of TiO_2 in water with light of wavelength $< 400\text{nm}$ generates excess electrons in the conduction band (e^-_{CB}) and positive "holes" (h^+_{VB}) in the valence band. At the surface, the holes either react with absorbed water or surface OH^- groups to form OH radicals. The OH radicals degrade organic molecules to carbon dioxide and water. Inorganics, such as the cyanide ions and sulphite ions, are oxidized to cyanate ions (OCN^-) and sulphate ions, respectively.

The Nutech Environmental system features a photoreactor that consists of a jacket, a lamp and a photocatalytic sleeve. The lamp emits UV light in the 300-400 nm range and is coaxially mounted within the jacket. Around the lamp is a fiberglass mesh coated with TiO_2 (anatase). Contaminated water flows through the photocatalytic sleeve. The mesh creates turbulent mixing due to open pore configuration and large surface area. At the TiO_2 surface, the pollutants are converted to carbon dioxide, water, and halide ions (if the organic pollutant contains halogen atoms). After passing through the reactors, water, in the case of multi-pass operations, returns to the reservoir. This technology does not generate any residual material that may need further treatment or disposal; complete destruction takes place.

PSI Technology Company. Andover, MA. Midas Process for Solids Contaminated with Organics and Metals. PSI Technology has developed a two-step process, Metals Immobilization and Decontamination of Aggregate Solids (MIDAS), which involves the destruction of organics and immobilization of metals. The first step is a modified thermal process for the destruction of organics in contaminated soils, sediments and sludges. Solids are combined with sorbents and processed via a heat treatment step, which destroys the organics. As an alternate approach, soils are incinerated first to destroy organics. The resulting flash (containing the leachable metal species) is mixed with the sorbent and then heat-treated to produce a residue that is non-leachable. The use of either strategy (or their combination) for soils remediation will depend on the type and level of organics and metals in the contaminated matrix.

In the second step, complete immobilization of heavy metal species in both treated soil and in the flash component is accomplished with the use of sorbents, pelletizing, and subsequent heat treatment. The only solid residues exiting the process are treated solids and treated flash

pellets, both of which are nonhazardous and decontaminated.

Standard air pollution control devices are used to clean the effluent gas stream. HCL formed from the oxidation of chlorinated organics is cleaned by alkaline scrubbers.

Pulse Sciences, Inc. Agoura Hills, CA. X-Ray Treatment for Organic Waste. The Pulse Sciences technology utilizes an X-ray processing concept for the destruction of organic contaminants in soil and water. The X-rays penetrate gases, liquids, and solids where they deposit energy primarily through ionizing collisions. Such collisions generate a shower of energetic secondary electrons within the material which are effective in breaking up complex molecules, and in forming chemically reactive radicals which react with them. Electron beam processing has been established as highly effective for destruction of organic compounds.

The mechanism by which the contaminants are removed is primarily dependent on the substrate. In oxygenated water the primary reactant is the OH radical. This kinetic mechanism is expected to play an important role in nonaqueous matrices as well, due to the presence of moisture in the contaminated soils, sludges and sediments. It is expected that complete mineralization of contaminants will occur and undesirable air emissions and waste residuals will be entirely eliminated.

The Linear Induction Accelerator (LIA) is a high power electron accelerator capable of operating reliably at the high energy levels and power levels required for waste treatment applications. The operating principle of the LIA is analogous to that of an electrical transformer. A pulsed voltage is applied to a single conductor turn placed around a ferrite core which is contained within an induction cell. The electron beam passes through a series of these cells where it is accelerated in the gaps between the cell electrodes to obtain a cell voltage equal to the sum of the cell voltages. Because the

induction cells are non-resonant structures, high beam currents are readily achieved.

Once formed, the beam electrons pass into an acceleration module where additional energy (up to 840 keV) is added to the beam. Pulsed magnetic solenoids are incorporated into the beamline to guide the beam and insure stability.

Purus, Inc. San Jose, CA. Destruction of Organics in Air Phase, UV/Oxidation. This technology is based on photolytic oxidation for the destruction of volatile organic compounds (VOCs) in air and groundwater. The emerging technology research is directed toward the use of the process for the destruction of organics in the air phase. The treatment system design embodies the use of a pulsed plasma xenon ultraviolet light (UV) source that emits short wavelength light at very high intensities. Air stripping or vacuum extraction are employed to convert contaminants into the vapor phase, where the treatment process transforms the organics into less hazardous compounds. This process can also treat VOCs in the aqueous phase.

Direct photolysis does not involve the formation of the hydroxyl radical as an intermediate step, as does conventional advanced oxidation processes. Direct photolysis occurs when sufficient UV light energy is absorbed by the organic contaminant, transforming atomic elements to higher energy states and causing molecular bonds to break. The quantity of light absorbed depends on the ability of the UV light source to emit wavelengths in the regions absorbed by the contaminant. The feature of the Purus technology is the ability to shift the maximum of the UV spectral output to match the absorption characteristics of the organics of interest.

The Purus technology utilizes vacuum extraction or air stripping to volatilize organic compounds. VOCs enter the reactor where a light source is generated by a high temperature xenon plasma contained within a chamber of UV

transmissive quartz. The plasma is produced by pulse discharge of electrical energy across two electrodes contained in the quartz chamber. Residence times are on the order of seconds which allows for continuous flow in the envelope. Temperature and average current are regulated in the reactor where VOC destruction occurs.

Vortec Corporation. Collegeville, PA. Vitrification Technology. The Vortec technology is an oxidation/vitrification process for remediation of soils, sludges, and sediments that have organic, inorganic, and heavy metal contamination, including radioactive components. The system can oxidize and vitrify materials introduced as slurries, thus mixing contaminated or waste oils with various hazardous solids.

The Vortec system utilizes a cyclone reactor and a Counter-Rotating Vortex (CRV) combustion heater as key elements in the process assembly. Waste oxidation is initiated in the precombustor and is completed in the CRV heater. Basic melting processes involve feedstock suspension preheating/oxidation followed by melting in the d-cyclone reactor. High local flame temperatures ($> 4000^{\circ}\text{F}$) can be achieved in the process by the use of preheated combustion air at approximately 1200°F . In spite of local flame temperatures, NO_x emissions have been demonstrated to be less than 100-200 ppm. The resulting product is expected to be nontoxic by the EPA Toxicity Characteristic Leaching Procedure (TCLP) standards.

The unique features of the Vortec process include 1) the capability to process solid waste with both organic and heavy metal contaminants; 2) multi-fuel capability which allows for the selection of economical fuels and possibly the use of waste fuels; 3) single unit capacities of 10 ton/day to greater than 300 tons/day, with the capability of modularization to achieve large volume processing; 4) oxidation of organic contaminants in the materials vitrified, thus

improving system efficiency; 5) toxic by products of the flue gas cleanup recycled to extinction; and 6) production of a product which provides for long term immobilization of heavy metals and toxic organics.

Warren Spring Laboratory. Herts, England. Physical Process Techniques for Treatment of Contaminated Soils. Warren Spring Laboratory will investigate the application of feed preparation and mineral processing techniques for treatment of soil contaminated with metals, petroleum hydrocarbons, and polynuclear aromatic hydrocarbons.

Feed preparation processes to be evaluated include scrubbing, classifying, and cycloning. Mineral processing techniques including flotation, flocculation, high and low intensity magnetic separation, and gravity techniques will also be investigated. The processes will be taken to pilot-scale culminating in an integrated system for the treatment of contaminated soil.

Feed samples will be subjected to scrubbing and attritioning procedures with associated size fractionation and chemical analysis to evaluate the deployment of metals/organics. After feed preparation, samples will be subjected to magnetic separation using high gradient and high intensity methods for metals separation.

Flotation procedures for organics will utilize a range of further types (alcohols, polyglycols, and cresols) to be evaluated over a range of pH values to maximize organics recovery and increase selectivity with respect to solids. Metals flotation will be based on the comparison of different sulphydric collectors including zanthates, thiophosphates, thionocarboamates, and zanthogen formates. The separation of organic and metal phases will be examined using selective flocculation techniques. Tailing samples will be subjected to heavy liquid centrifuge techniques to assess the presence of liberated metal phases and the potential of subsequent gravity separation.

Western Product Recovery Group, Inc. Houston, TX. Process for Sludge and Soils Contaminated with Organics and Heavy Metals. The coordinate, chemical bonding, and adsorption (CCBA) process converts heavy metals in soils, sediments, and sludges to non-leaching silicates. The technology also has the capability to oxidize organics in the waste stream, converting the ash to a glass-like ceramic. The consistency of the residual can vary from a soil/sand density to a ceramic aggregate form. The residual can be placed back in its original location or used as a substitute for conventional aggregate.

The technology utilizes specific clays as the necessary structure with cation exchange capacity to provide sites for physical/chemical bonding of heavy metals to the clay. The process will thermally destroy organics in the waste processed. The residue from the technology is an inert ceramic product, free of organics, with metal silicates providing the molecular bonding structure to preclude leaching.

The technology is designed for continuous flow of the entering and outgoing contaminant streams. The input stream is carefully rationed with the clay following an intense mixing process. Densification of the mixture is performed to produce a green pellet form necessary for the desired end product. Direct firing of the pellet in the kiln slowly brings the pellet temperature to 2000°F. As the temperature in the kiln rises, organics on the surface of the pellet are oxidized and organics inside the pellet are pyrolyzed. The ceramic pellet reaches a temperature at which the available silica forms the final product containing metal silicates. The off-gas from the kiln is processed in a wet scrub operation before release to the atmosphere.

4. Summary

The SITE Emerging Technology Program has stimulated broad interest from the private sector since its inception in 1987, as indicated by more than 320 applicants to the program. Emerging technologies are becoming more sophisticated and are advancing into pilot-scale operations. This illustrates their capability to develop into commercially available technologies. Further development of programs like the ETP will provide quality data and the potential to commercialize technologies with credibility.

5. High Interest Areas for Emerging Technology Program

Various developing technologies in the Emerging Technology Program have drawn high interest from the general public and potential users. Each technology presents a unique process and has been developed at different levels by the researcher or developer. In addition, several developers are expanding awareness of their technologies to the user community. This is being done in various ways: through demonstration of an emerging process to the public, presenting papers on their research and development, forming conferences focusing on the specific technology, applying the technology in a pilot-field demonstration to gain additional data, and using the research effort to treat and destroy hazardous waste material while in the ETP.

Each technology in the ETP has features that deserve highlighting; however, the following mentions only the major areas that have been outstanding during 1991.

Nutech Environmental, an advanced oxidation technology uses titanium dioxide (TiO_2), in combination with ultraviolet radiation producing highly reactive hydroxyl radicals. The novel aspect of the Nutech technology is the incorporation of a TiO_2 semiconductor material

imbedded in a fiberglass mesh which lines the photolytic reactor. This developer is forming an international conference to take place in the fall of 1992 in London, Ontario, Canada. The conference is on TiO_2 Photocatalytic Purification and Treatment of Water and Air. This technology is progressing extremely well with excellent data and has demonstrated high public interest.

Bio-Recovery Systems, Inc. (BRS) has successfully completed the ETP. The process has the ability to immobilize algae to adsorb mercury from contaminated groundwater. The developer has been invited to participate in the SITE Demonstration Program to field-demonstrate the technology. As a result of BRS's participation in the ETP, the company was hired by the Department of Energy (DOE) to perform bench-scale treatability studies to establish treatment protocols and to optimize an AlgaSORB/ion exchange technology system to remove and recover toxic metal ions from contaminated groundwaters collected from three DOE sites (Savannah River, Hanford, and Oak Ridge). The metals of interest were mercury, chromium, and uranium.

Babcock and Wilcox's Cyclone Furnace technology was studied from October 1989 to June 1991 under the ETP. The Cyclone Furnace is a vitrification technology which is potentially useful in the treatment of soil contaminated with both organic chemicals and metals. During the study funded by the ETP, the ability of the Cyclone Furnace to vitrify metal contaminated soil was studied by treating EPA's Synthetic Soil Matrix (SSM) contaminated with 7000 ppm lead, 1000 ppm cadmium and 1500 ppm chromium. As a result, a SITE demonstration of the Cyclone Furnace was conducted in November 1991 in which the feed material (again SSM) contained non-radioactive surrogates as well as organic and heavy metal contaminants. The objective of these tests was to determine how well the Cyclone Furnace could treat mixed waste. Because of the preliminary studies completed under the ETP,

Babcock and Wilcox was able to ready the Cyclone Furnace for a SITE demonstration in less than 5 months. Because Babcock and Wilcox had the opportunity to optimize the Cyclone Furnace for the treatment of SSM during the Emerging Technology study, the successful demonstration was completed without significant operational problems.

Electrokinetics, Inc.'s investigation into the removal of heavy metals precipitates and radionuclides was completed in July 1991. Uranium removal tests at 100 pCi/g of activity demonstrated that the process removed uranium from Georgia kaolinite. The process removed 85 to 95% of the loaded uranium in regions close to the anode. In addition, the removal of lead, chromium, and cadmium ranged from 75 to 95%. The developer has presented test results at the American Chemical Society's Industrial and Engineering Chemistry Special Symposium in Atlanta, Georgia in October 1991, and the International NATO Exposition in Washington DC in November 1991.

Colorado School of Mines, Constructed Wetlands Treatment for Toxic Metal Contaminated Waters technology uses natural geochemical and biological processes inherent in a manmade wetland ecosystem to accumulate and remove metals from influent waters. The treatment system incorporates principal ecosystem components found in wetlands, including organic soils, microbial fauna, algae, and vascular plants. This project has successfully completed development under the ET program and has been invited for participation in the SITE Demonstration Program. In 1990, the pilot-scale constructed wetlands system won a national honor award in the Engineering Excellence Award Competition of the American Consulting Engineers Council. The final year of funding for the project under the ETP was completed in 1991. As a result of this technology's success in the ETP, it has been included in the Records of Decision (ROD) for the Clear Creek site in Colorado and the Buckeye Landfill site in eastern Ohio. The full

scale constructed wetlands employed to remediate the discharge of the Burleigh Tunnel on the Clear Creek/Central City Superfund Site near Silver Plume, Colorado will be evaluated as a SITE demonstration project with the State of Colorado. Another goal of this project is the development of a manual that discusses design and operating criteria for construction of a full-scale wetland for treating acid mine discharges. This manual will be available in early 1992.

The Center for Hazardous Materials Research (CHMR) technology uses secondary lead smelters to recover lead from waste lead-acid battery rubber casings removed from abandoned waste sites. This project, which began in the fall of 1991, has attracted significant interest from various Superfund sites around the country as well as interest from the Bureau of Mines and the Agency for Housing and Urban Development (HUD). Several Superfund Remedial Project Managers (RPMs) have offered material at their sites for use in this project, and HUD (Montgomery County, Pennsylvania) has offered to pay to send waste material containing lead based paint chips. Region 3, for the Tonnoli Site in Pennsylvania, requested that Exide perform a treatability study in early September 1991 as a part of the Remedial Investigation and Feasibility Study (RI/FS) work for that site. CHMR and Exide performed the treatability study as part of the ETP, processing 120 tons of material. Data indicated a successful study, and other sources are inquiring about using the process for remediation action.

Purus Technology is an advanced oxidation process that is using a xenon pulsed-plasma flashlamp that emits short wavelength ultraviolet (UV) light at very high intensities. The process strips the contaminants into the vapor phase, where the UV treatment converts the volatile organic compounds (VOCs) into nonhazardous compounds. Direct photolysis does not involve the formation of the hydroxyl radical. Thus, direct photolysis occurs when sufficient UV light energy is absorbed by the organic contaminant,

transforming electrons to higher energy states and causing molecular bonds to break. Various papers have been given by the developer to discuss results to date. Because of the high visibility of the process in the field, a Visitors' Day was held to demonstrate this process in the air phase at Lawrence Livermore National Laboratories (LLNL) in January 1992. This is the result of research supported by the ETP. Remediation efforts at LLNL using this technology will be implemented in 1992. This process is also applicable to aqueous media.

C. MONITORING AND MEASUREMENT TECHNOLOGIES PROGRAM

Monitoring, measurement, and other site characterization technologies are an integral part of and required in several phases of the Superfund remedial process. The costs to characterize a Superfund site are substantial. As much as 80 percent of the costs of the remedial investigation/feasibility study process are attributable to site characterization. These costs are a direct result of sampling, analysis, and the associated quality assurance activities. Therefore, the capabilities of field screening and field analytical methods to yield immediate or quick-turnaround environmental data will (1) result in major savings in both cost and time for Superfund remediation, (2) will decrease the human and ecological risks associated with contaminants at Superfund sites, and (3) will enhance EPA's ability to manage such risks. In addition to the obvious advantages offered by field methodologies (i.e., generation of real-time data, higher sampling density, and effective detection of hot spots), they also improve the pace of clean-up at a reduced cost and instill a higher degree of confidence in the clean-up.

The two categories of technologies included in the SITE Program are (1) treatment technologies; which may serve as alternatives to

land disposal of hazardous wastes, and (2) monitoring and measurement technologies for contaminants occurring at hazardous waste sites. The Monitoring and Measurement Technologies Program (MMTP) is a much smaller component of SITE which addresses the very critical needs of field screening. It is administered by the Environmental Monitoring Systems Laboratory in Las Vegas, Nevada (EMSL-LV). Historically, EMSL-LV, and the other Office of Modeling, Monitoring Systems and Quality Assurance (OMMSQA) laboratories, have been supporting the development and demonstration of innovative monitoring and measurement techniques as part of OMMSQA's mission. The MMTP allows synergism to occur in identifying and demonstrating relevant technologies that exist within and outside the federal government and which may provide less expensive, better, faster, and/or safer means to characterize contamination at hazardous waste sites.

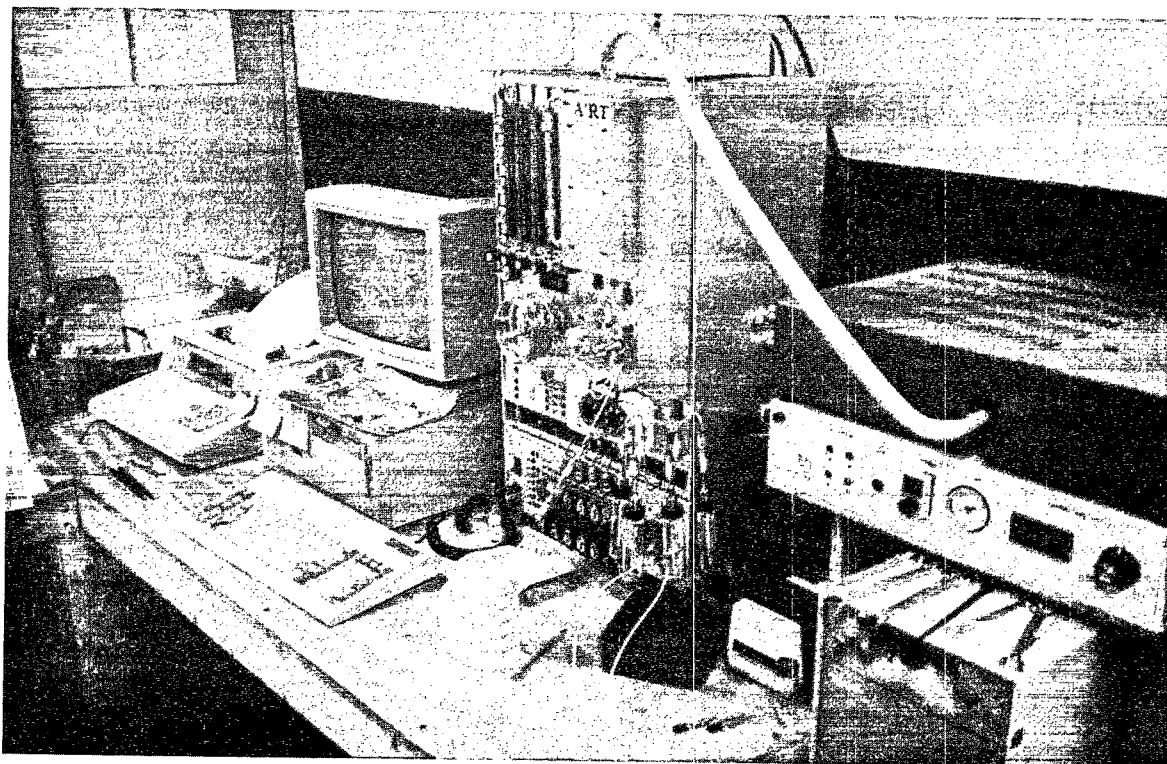
Products from the various research, development, and demonstration activities conducted under MMTP enhance EPA's ability to perform statistically valid sampling and field analytical programs that yield effective site characterization coupled with immediate or quick-turnaround environmental data acquisition.

The MMTP has focused on emerging technologies as well as those that are ready for field demonstration. The following sections discuss the FY 1991 technology demonstration activities and the plans for FY 1992 and beyond.

1. Technology Demonstration Activities

In FY 1991 one innovative monitoring technology demonstration was conducted under the MMTP. The Analytical and Remedial Technology, Inc. (A+RT), Volatile Organic Analysis System (AVOAS) (see photograph 6) was demonstrated at the Wells G&H Superfund site in Woburn, MA (EPA Region 1). The AVOAS consists of a manifold which permits sampling from multiple locations; an injector which extracts the volatile organic compounds (VOCs) from aqueous samples by a proprietary process similar to purge and trap and injects them into a gas chromatograph; and software that provides system control and storage of data. The advantages of the AVOAS are that it eliminates the steps typically associated with collection and analysis of water samples and provides real-time results.

The purpose of this demonstration was to evaluate the performance of the technology at a site where groundwater is contaminated with volatile chlorinated hydrocarbons. The demonstration was designed to detect sources of variability between the field and conventional laboratory techniques. On the basis of results from the study, it was concluded that the AVOAS is capable of providing the benefits of automated sampling and analysis, as proposed. AVOAS recoveries for samples spiked with known concentrations of VOCs were higher than those of standard EPA Method 502.2, and were close to 100 percent for most analytes. Precision was within limits acceptable for VOC analyses (within 30 percent relative standard deviation). The Project Report describing the demonstration, the results, recommendations, and conclusions will be available in FY 1992.



Photograph 6: Analytical and Remedial Technology, Inc.'s volatile organic analysis system (AVOAS)

The research, development, and demonstration of air monitoring technologies is another important facet of the MMTP. In FY 1991, planning was initiated for a demonstration of four technology categories at the French Limited Superfund site located near Crosby, Texas. The demonstration will include seven commercially-available gas chromatographs, four whole-air canister sector samplers, a long-path length Fourier transform infrared spectrometer, and bioaerosol samplers. This demonstration will be conducted in conjunction with the pilot testing of a large-scale bioremediation. The demonstration is expected to occur in the second quarter of FY 1992.

FY 1991 was the first full year of work on a new transient electromagnetic (TEM) geophysical method. The TEM SITE Program activity is designed to evaluate the effectiveness of new three-D interpretation methods and promote their acceptance if merited. This project will:

- Provide insights to develop procedure and policies that encourage informed selection and use of TEM measurements
- Lead to the identification of constraints and limitations on the use of TEM measurements during the RI/FS process
- Demonstrate the application of 3-D modeling techniques for the interpretation of electromagnetic data

In FY 1991, the MMTP demonstration program objective was to acquire a suitable TEM data set over a selected test site and to evaluate the data set for use in three-D interpretations. An appropriate site was identified in Colorado near the Rocky Mountain Arsenal. The site was considered characteristic of a typical hazardous waste site in that it has a certain degree of electromagnetic noise due to the close proximity of human activities. A necessary part of environmental geophysics must be to salvage interpretable data sets from noisy

areas. Data were collected during two field excursions, in February and September 1991. Preliminary interpretation of the data revealed that seasonal variations and cultural interferences introduce some degree of error in the data set which can impact data reduction using the multi-dimensional modeling approach. Solutions to these problems are part of the FY 1992 activities.

Other Activities

In February 1991, the *Second International Symposium on Field Screening Methods for Hazardous Wastes and Toxic Chemicals* was held in Las Vegas, Nevada. The agency was the primary sponsor. The Departments of Defense and Energy, the National Institutes for Occupational Safety and Health, and others were cosponsors of this important technology transfer activity.

The focus of the symposium was to bring an international view to the problems involved with characterizing and monitoring hazardous waste sites using field screening techniques and methods and for showcasing promising alternative technologies and methods. Tremendous advances have been made in portable and transportable field technologies that can generate real-time data. The symposium brought together technology users from industry, state and federal government agencies, and international agencies with instrument developers and vendors, academia, and venture capitalists. The symposium successfully transferred technology among interested users.

The symposium proceedings was produced and distributed in FY 1991. The proceedings is a collection of 60 oral presentations, 60 poster presentations, and session discussions between authors and the audience.

In addition to the proceedings, four other reports were completed:

1. Poziomek, E.J. et al., 1991. SITE Program Laboratory Demonstration: Ion Mobility Spectrometry. EPA Report EPA/600/X-91/133.
2. Poziomek, E.J. and E.N. Koglin, 1991. Assessment of Available and Emerging Technologies for Field Screening and Analysis of Contaminants at Superfund Sites. EPA Report EPA/600/X-91/138.
3. Chaloud, D. et al., 1991. Demonstration of the Brunker Mobile Environmental Monitor. EPA Report EPA /600/X-91/079.
4. McClenny, W.A. et al., 1991. Superfund Innovative Technology Evaluation: The Delaware SITE Study, 1989. EPA Report EPA/600/3-91/071.

2. Future Activities

A number of exciting demonstrations and research and development (emerging technologies) opportunities are in progress or under consideration:

- As mentioned previously, multiple technologies will be demonstrated at the French Limited Superfund site in the second quarter of FY 1992. The demonstration will include seven commercially-available gas chromatographs, whole air canister sector samplers, a long-pathlength Fourier transform infrared spectrometer, and bioaerosol samplers. This demonstration will be conducted in conjunction with the pilot testing of a large-scale bioremediation. This demonstration is being coordinated by the Atmospheric Research and Exposure Assessment Laboratory in Research Triangle Park, NC.

- In FY 1990, an immunoassay field kit for measuring benzene, toluene, ethylbenzene, and xylene (BTEX) in water was identified as an excellent candidate for a SITE demonstration. During FY 1991, the field kit was evaluated in the laboratory to determine whether it was ready to go into the field. The laboratory demonstration was successful. A field demonstration will be conducted in the second and third quarters of FY 1992 in the Las Vegas, Nevada area. This demonstration is being coordinated by EMSL-LV.
- In FY 1991, a number of field screening methods for measuring polychlorinated biphenyls (PCB) in soils were identified as excellent candidates for a SITE demonstration. These methods include two immunoassay field kits, an analytical method for using a portable gas chromatograph, and an electrochemical technique. This demonstration will be conducted in conjunction with a cleanup at the Department of Energy's Kansas City plant in the fourth quarter of FY 1992. This demonstration is being coordinated by EMSL-LV.
- Demonstration preparation is continuing on the transient electromagnetic geophysical method. In FY 1992, it is expected that the technology will be demonstrated in the field and that the modified data interpretation algorithm will be applied.
- Preparations are under way for the *Third International Symposium on Field Screening Methods for Hazardous Wastes and Toxic Chemicals*. The symposium, sponsored by the Air & Waste Management Association and EPA, is planned for February 1993 in Las Vegas, Nevada. A proceedings document will be produced following the symposium.

D. TECHNOLOGY INFORMATION SERVICES

Technology Information Services is an integral part of the SITE Program, involving public participation, information dissemination, and technical assistance to other parts of the SITE Program. The purpose of these technology transfer activities is to develop a framework for exchanging information about existing innovative treatment technologies, to help environmental decisionmakers evaluate hazardous waste clean-up options. This information discusses the benefits and shortcomings of specific technologies. Initially, the SITE Program's primary audience for such information was regional and state managers of Superfund clean-up activities. The audience has grown to include regional and state managers of RCRA corrective action clean-up activities, other federal and state agencies involved in hazardous waste mitigation and clean-up, potentially responsible parties (PRPs), the engineering community, the pollution control industry, and the public, including affected communities, public interest groups, and local officials. Several of the developers involved in the FY 1991 SITE Program have indicated to EPA that information generated by program activities has greatly helped potential users/buyers familiarize themselves with innovative technologies and their capabilities.

The major accomplishments of Technology Information Services during FY 1991 include the following:

- EPA hosted an international forum on innovative hazardous waste treatment technologies that was attended by approximately 800 representatives from the U.S. and several foreign countries. The purpose of the conference was to introduce promising international technologies through technical papers and poster displays, and to discuss the status of the

technologies tested under the SITE Program.

- Numerous publications were prepared and distributed, including three additional Technology Evaluation Reports, five Applications Analysis Reports, eight SITE videos, two program status brochures, and numerous project fact sheets, technical project update bulletins, technical papers and posters.
- Visitors' Days for six demonstrations, including on-site briefings, were held to introduce the public to the technology and to observe field activities. Attendance ranged from 25 to 130 visitors.

1. SITE Reports, Brochures, Publications, and Videos

SITE reports, including Technology Evaluation Reports (TER) and Applications Analysis Reports (AAR), are prepared following demonstration and analysis of laboratory findings. The TER documents the performance data resulting from the demonstration. This report includes a description of the process and site characteristics, the objectives of the demonstration, sampling and analysis procedures, performance data, and information about the QA/QC program. The TER also evaluates how and whether the objectives of the demonstration were met.

The AAR evaluates available information on the technology and presents the applicability of each technology to other site and waste characteristics. The scenarios presented in the AAR can be applied to both Superfund and RCRA corrective action clean-up activities. Limited copies and summaries of these reports are distributed by EPA, and additional copies are available through the National Technical Information Service for a fee. A list of publications, including information on obtaining the documents, is provided in Appendix A.

SITE Program status brochures contain brief descriptions of the SITE Program, technologies currently being tested, and the progress and accomplishments of the program to date. Additionally, the brochure discusses how an interested party can obtain information about the SITE Program, who should apply, how to apply, what transpires under the program, and when the next solicitation for new participants will occur. The brochures are prepared annually for the RREL Symposium and the Superfund Conference and exhibition. Each year about 500 to 900 participants attend the RREL Symposium and 3,000 participants attend the Superfund Conference. The brochures enable potential SITE Program participants to familiarize themselves with the program's objectives and requirements and prepare their technologies for potential inclusion in the program. About 15,000 copies of each of these brochures were printed and distributed in FY 1991.

Monthly articles concerning the SITE Program are published in the *Journal of the Air and Waste Management Association*. The articles present the SITE Program and its progress and accomplishments to a variety of audiences.

Each year, EPA updates the *Superfund Innovative Technology Evaluation Program: Technology Profiles*, originally published in 1988. The document includes an overview of the SITE Program, a list of the program participants, and profiles on each technology, including a description of the technology, a discussion on waste applicability, the status of the demonstration, and an EPA and technology developer contact for further information. The Technology Profiles provide environmental decisionmakers and other interested individuals with a ready reference on technologies participating in the SITE Demonstration and Emerging Technology Programs. Developers indicated to EPA that the technology profiles were a very useful and primary source for inquiries about their technologies.

As part of each technology demonstration, a videotape is prepared documenting demonstration activities and discussing the results of the demonstration. The videotape gives regional and state site remediation managers and other interested parties a brief (10-12 minute) synopsis of the SITE Program, the technology being tested, demonstration goals and objectives, and the results of the demonstration. Each videotape includes actual footage of the treatment system in operation at the demonstration site and uses computer animation to further characterize the components of and processes within the system. Final videotapes of each completed demonstration are distributed to each of the regions, so that interested remediation managers can initially familiarize themselves with a particular technology that may be suitable as part of the clean-up remedy for their sites. See Appendix A for information on obtaining available videotapes.

2. Public Participation and Visitors' Days

Public participation is an integral part of the SITE Program. Public participation allows the program the opportunity to disseminate information widely and encourage interaction about innovative technologies to a variety of interested individuals and groups. Prior to the final selection of a demonstration site, a public notice and public comment period about the proposed demonstration are initiated. Public notices announcing the public comment period are usually presented in local newspapers and in fact sheets distributed to individuals on the mailing list for the site and to other potentially interested parties. Public Notice fact sheets have been sent to up to 3,200 persons for a particular demonstration. Following the public comment period, a responsiveness summary addressing any public concerns is developed.

During the demonstration, a Visitors' Day is sponsored by EPA to provide first-hand observation of the technology during field use and discussions with the SITE Program

Managers, developers and technical personnel. During the past six months, Visitors' Days were conducted for two demonstrations and were attended by federal, state, and local agency personnel, PRPs, individuals from the engineering and pollution control industry, technology competitors, the media, public interest groups, and citizens from the affected communities. The Visitors Days were attended by up to 110 persons, with many other individuals expressing interest but unable to attend. EPA provides a Visitors' Day packet to all individuals expressing interest in the technology demonstration. This community outreach tool is rather comprehensive, providing descriptions of the technology, the site, the waste, the goals and objectives of the demonstration, the sampling and the analysis parameters of the site, diagrams of the technology, and a list of contacts.

3. Conferences, Meetings, and Seminars

On June 11-13, 1991, EPA hosted the **Third Forum on Innovative Hazardous Waste Treatment Technologies: Domestic and International** in Dallas, Texas. The conference was attended by approximately 800 representatives from the U.S. and several foreign countries. During the conference, scientists and engineers representing government agencies, industry, and academia, attended 37 presentations describing successful case studies of physical/chemical, biological, thermal, and stabilization treatment methods. In addition, case studies of applied technologies were presented by EPA's Superfund contractors. Domestic and international scientists and vendors presented over 70 posters explaining their treatment methods and results.

EPA planned and coordinated the **Second International Symposium on Field Screening Methods for Hazardous Wastes and Toxic Chemicals**, which occurred February 12-14, 1991 in Las Vegas, Nevada. The purpose of the symposium was to bring an international view to

the problems and potential solutions involved with the characterization and monitoring of hazardous wastes and toxic chemicals. EPA received about 150 abstracts. The symposium had one plenary session, ten technical sessions, 60 poster presenters, and 70 technology exhibitors. About 800 delegates attended the conference, representing various federal and state agencies, technology developers, academicians, and venture capitalists.

Last year, in an effort to speed up the site selection process, EPA initiated **Regional SITE Coordinator's Meetings**, to identify potential site demonstration sites for new technologies recently accepted into the program. These meetings continued in FY 1991, with one taking place in Cincinnati, Ohio, following the receipt of proposals from the SITE-006 solicitation. The objective of these meetings was expanded in FY 1991 to include obtaining information from the regions about the kind of alternative technologies they most need to remedy regional hazardous waste clean-up operations. To accomplish this objective, RREL designated members of its staff to serve as Regional Coordinators.

Preproposal Conferences on SITE Solicitations are held annually. These conferences present the SITE program to developers in an effort to attract new participants to the program.

4. Electronic Information Systems

In order to facilitate the transfer of information on alternative technologies, several electronic databases have been developed by EPA. The following paragraphs describes these databases.

Alternative Treatment Technology Information Center (ATTIC) is a comprehensive, automated information retrieval system that integrates data on hazardous waste treatment technologies into a centralized,

searchable source. Initiated in November 1987, a prototype version became operational in May 1989. ATTIC's four major components include a hotline, an electronic bulletin board, a reference library, and a computerized information network. Additionally, hard copies of information are provided upon request. The purpose of ATTIC is to provide users with technical information on alternative methods of hazardous waste treatment. The user community consists of EPA headquarters and regional staff, participating state environmental agencies, and numerous remediation contractors. ATTIC is available through any modem-equipped IBM compatible PC using standard communications software. Users can employ the system independently or use an ATTIC system operator to assist them.

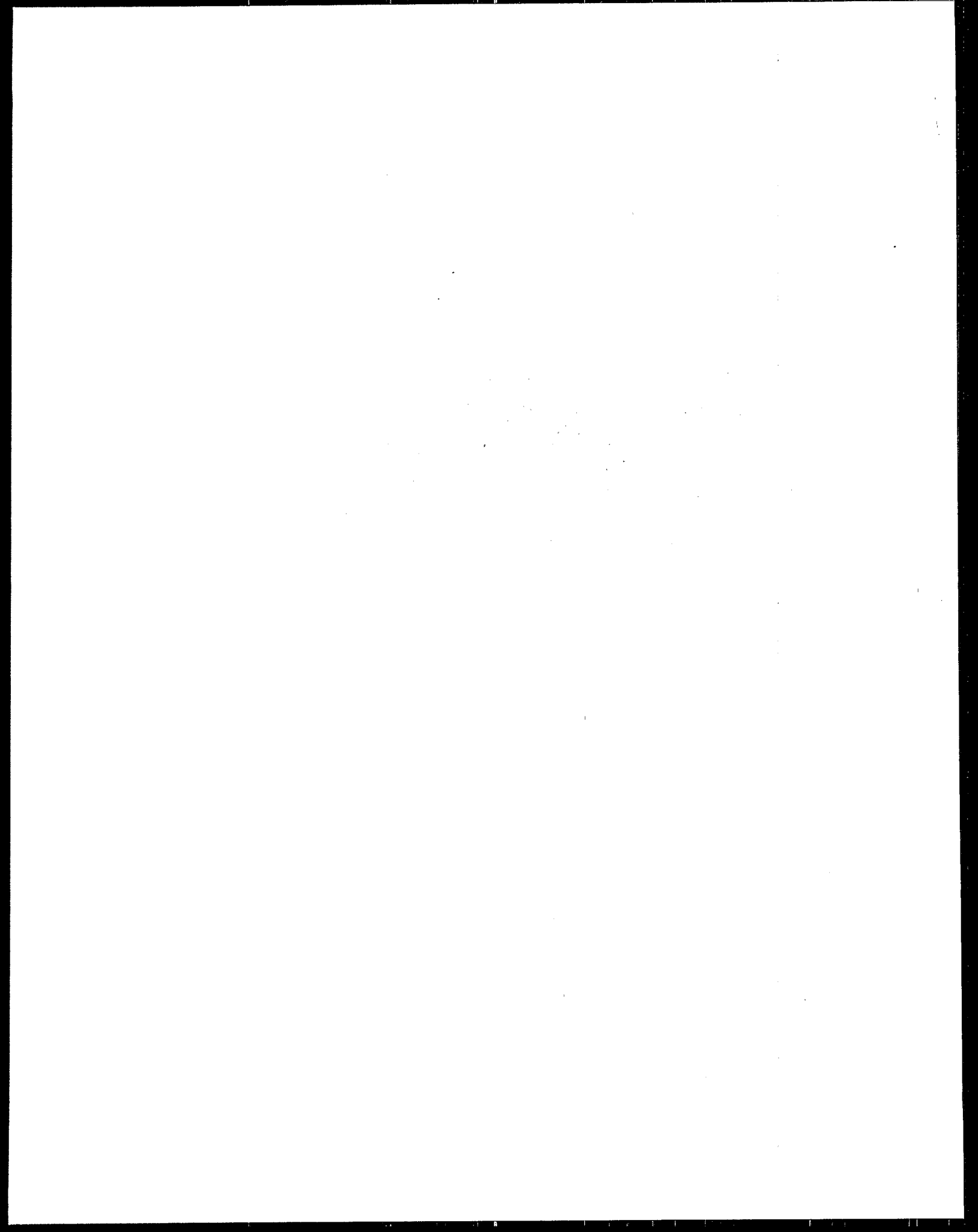
ATTIC contains data obtained from the SITE Program and other federal and state agencies, including abstracts and executive summaries from over 900 documents and reports, which are the core of the ATTIC Database. Contributors to the ATTIC Database are the SITE Program, states, industry, North Atlantic Treaty Organization (NATO), DOD/DOE, Records of Decisions (RODs), and treatability studies. In addition to the ATTIC Database, the ATTIC system contains resident databases already developed, as well as an online commercial database. ATTIC resident databases include RREL (Water) Treatability Database; Robert S. Kerr Environmental Research Laboratory (RSKERL) Soil Transport and Fate Database; EPA Library Hazardous Waste Collection Database; Cost of Remedial Action Model; and Geophysics Advisor Expert System.

The OSWER CLU-IN was set up to facilitate communication and technology transfer among EPA staff in regional offices, headquarters, state and local government personnel, EPA contractors, and research laboratories. The CLU-IN offers up-to-date information about the status of each SITE technology demonstration, as well as providing

messages, files, computer programs, databases, and information on conferences.

EPA's Technical Information Exchange (TIX) Computerized On-Line Information System (COLIS) provides technical information involving hazardous waste technologies and assists users in locating materials from other sources. The system contains the complete text of each published SITE Program AAR.

EPA most recently developed the **Vendor Information System for Innovative Treatment Technologies (VISITT)**. This database contains information on 155 technologies offered by 97 developers. Of the 97, several are current and former SITE Program participants. Contact the VISITT hotline (1-800-245-4504) to request diskettes and a user manual.



APPENDIX A
REPORTS AVAILABLE

1. The first part of the document is a list of names and addresses of the members of the committee who have been appointed to investigate the matter.

2. The second part of the document is a list of the names and addresses of the members of the committee who have been appointed to investigate the matter.

3. The third part of the document is a list of the names and addresses of the members of the committee who have been appointed to investigate the matter.

4. The fourth part of the document is a list of the names and addresses of the members of the committee who have been appointed to investigate the matter.

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9. The ninth part of the document is a list of the names and addresses of the members of the committee who have been appointed to investigate the matter.

10. The tenth part of the document is a list of the names and addresses of the members of the committee who have been appointed to investigate the matter.

11. The eleventh part of the document is a list of the names and addresses of the members of the committee who have been appointed to investigate the matter.

12. The twelfth part of the document is a list of the names and addresses of the members of the committee who have been appointed to investigate the matter.

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14. The fourteenth part of the document is a list of the names and addresses of the members of the committee who have been appointed to investigate the matter.

15. The fifteenth part of the document is a list of the names and addresses of the members of the committee who have been appointed to investigate the matter.

16. The sixteenth part of the document is a list of the names and addresses of the members of the committee who have been appointed to investigate the matter.

17. The seventeenth part of the document is a list of the names and addresses of the members of the committee who have been appointed to investigate the matter.

18. The eighteenth part of the document is a list of the names and addresses of the members of the committee who have been appointed to investigate the matter.



EPA

**DOCUMENTS AVAILABLE FROM THE
U.S. EPA RISK REDUCTION ENGINEERING LABORATORY
SUPERFUND TECHNOLOGY DEMONSTRATION DIVISION**

General Publications

- ☐ Technology Profiles (EPA/540/5-91/008)
- ☐ Report to Congress (EPA/540/5-91/004)

Demonstration Project Results

American Combustion - Oxygen Enhanced Incineration

- ☐ Technology Evaluation (EPA/540/5-89/008)
- ☐ Applications Analysis (EPA/540/A5-89/008)

AWD Technologies - Vapor Extraction/Vacuum Stripping

- ☐ Applications Analysis (EPA/540/A5-91/002)

BioTrol - Biological Aqueous Treatment

- ☐ Applications Analysis (EPA/540/A5-91/001)

CF Systems Corp. - Solvent Extraction

- ☐ Technology Evaluation (EPA/540/5-90/002)
- ☐ Applications Analysis (EPA/540/A5-90/002)

Chemfix Technologies, Inc. - Chemical Fixation/Stabilization

- ☐ Technology Evaluation (EPA/540/5-89/011a)
- ☐ Applications Analysis (EPA/540/A5-89/011)

DuPont/Oberlin - Membrane Microfiltration

- ☐ Applications Analysis (EPA/540/A5-90/007)

Hazcon - Solidification

- ☐ Technology Evaluation (EPA/540/5-89/001a)
- ☐ Applications Analysis (EPA/540/A5-89/001)

IWT In-Situ Stabilization

- ☐ Technology Evaluation (EPA/540/5-89/004a)
- ☐ Applications Analysis (EPA/540/A5-89/004)

Shirco-Infrared Incineration

- ☐ Technology Evaluation - Peake Oil (EPA/540/5-88/002a)
- ☐ Technology Evaluation - Rose Township (EPA/540/5-89/007a)
- ☐ Applications Analysis (EPA/540/A5-89/010)

Soliditech, Inc. - Solidification

- ☐ Technology Evaluation (EPA/540/5-89/005a)
- ☐ Applications Analysis (EPA/540/A5-89/005)

Toxic Treatments - In Situ Steam/Hot-Air Stripping

- ☐ Applications Analysis (EPA/540/A5-90/008)

Terra Vac - Vacuum Extraction

- ☐ Technology Evaluation (EPA/540/5-89/003a)
- ☐ Applications Analysis (EPA/540/A5-89/003)

Ultrox International - UV Ozone Treatment for Liquids

- ☐ Technology Evaluation (EPA/540/5-89/012)
- ☐ Applications Analysis (EPA/540/A5-89/012)

Emerging Program Reports

Bio-Recovery Systems Removal and Recovery of Metal Ions from Groundwater

- ☐ EPA/540/5-90/005a

Development of Electro-Acoustic Soil Decontamination (ESD) Process for In Situ Applications

- ☐ EPA/540/S5-90/004

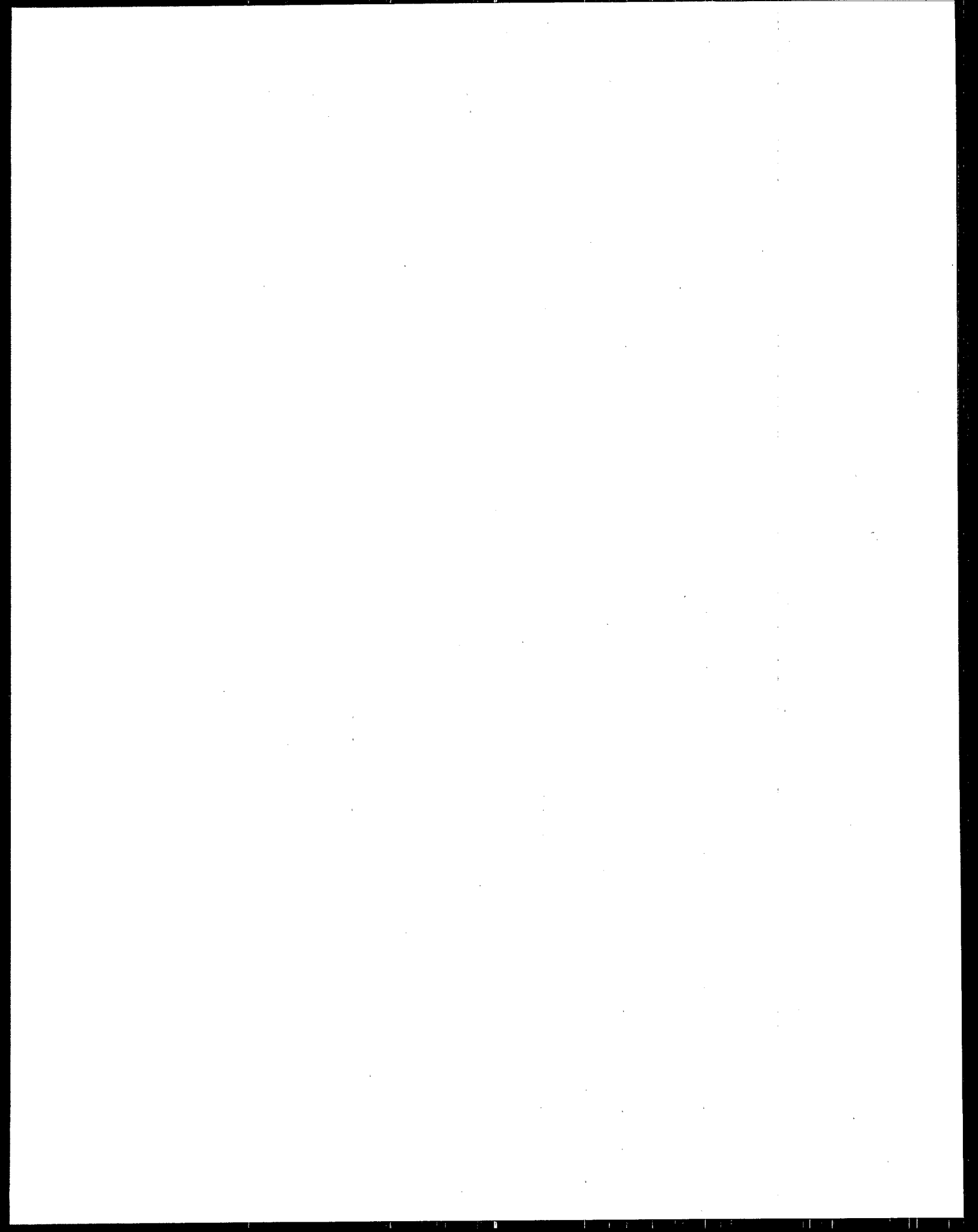
- ☐ Check here if you would like your name placed on the SITE mailing list

Your Name, Mailing Address, and Phone (please print)

MAIL THIS FORM TO:

ORD Publications
26 W. Martin Luther King Dr. (G72)
Cincinnati, Ohio 45268

* Documents ordered through ORD Publications are free of charge.



**FOSTER WHEELER ENVIRESPONSE, INC.
VIDEOTAPE REQUEST FORM**

_____, 1992

Foster Wheeler Enviresponse, Inc.
Attn: Ms. Marilyn Avery
8 Peach Tree Hill Road
Livingston, NJ 07039

Dear Ms. Avery,

Please send us the following USEPA-produced videotapes. I have completed the address information below and enclosed a check in the amount of \$_____ made payable to "Foster Wheeler Enviresponse" [\$35.00 per tape, plus \$10.00 additional per tape for international shipments].

<u>Copies</u>	<u>Number</u>	<u>Videotape Title</u>
___	S1	SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION (SITE) PROGRAM (6 technology demonstrations)
___	S2	SUPERFUND INNOVATIIVE TECHNOLOGY EVALUATION (SITE) PROGRAM (4 technology demonstrations)
___	S3	SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION (SITE) PROGRAM (4 technology demonstrations)
___	R1	RREL/RCB RESEARCH PROGRAM (5 programs)

(Contents of each tape are listed on the reverse side of this sheet.)

(Signed) _____

Title _____

Tapes should be sent to the following (Please Print):

NAME: _____

COMPANY: _____

ADDRESS: _____

CITY: _____ STATE _____ ZIP _____

(NO REQUESTS WILL BE HONORED WITHOUT PREPAYMENT BY PERSONAL OR COMPANY CHECK.)

**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
SUPERFUND TECHNOLOGY DEMONSTRATION DIVISION
RREL VIDEOTAPE ORDER FORM**

Videotapes documenting US EPA Risk Reduction Engineering Laboratory (RREL) projects have been combined in 1/2" VHS (NTSC format) composite tapes. Each tape is available at the cost of \$30.00 plus \$5.00 shipping/handling fee (per copy).

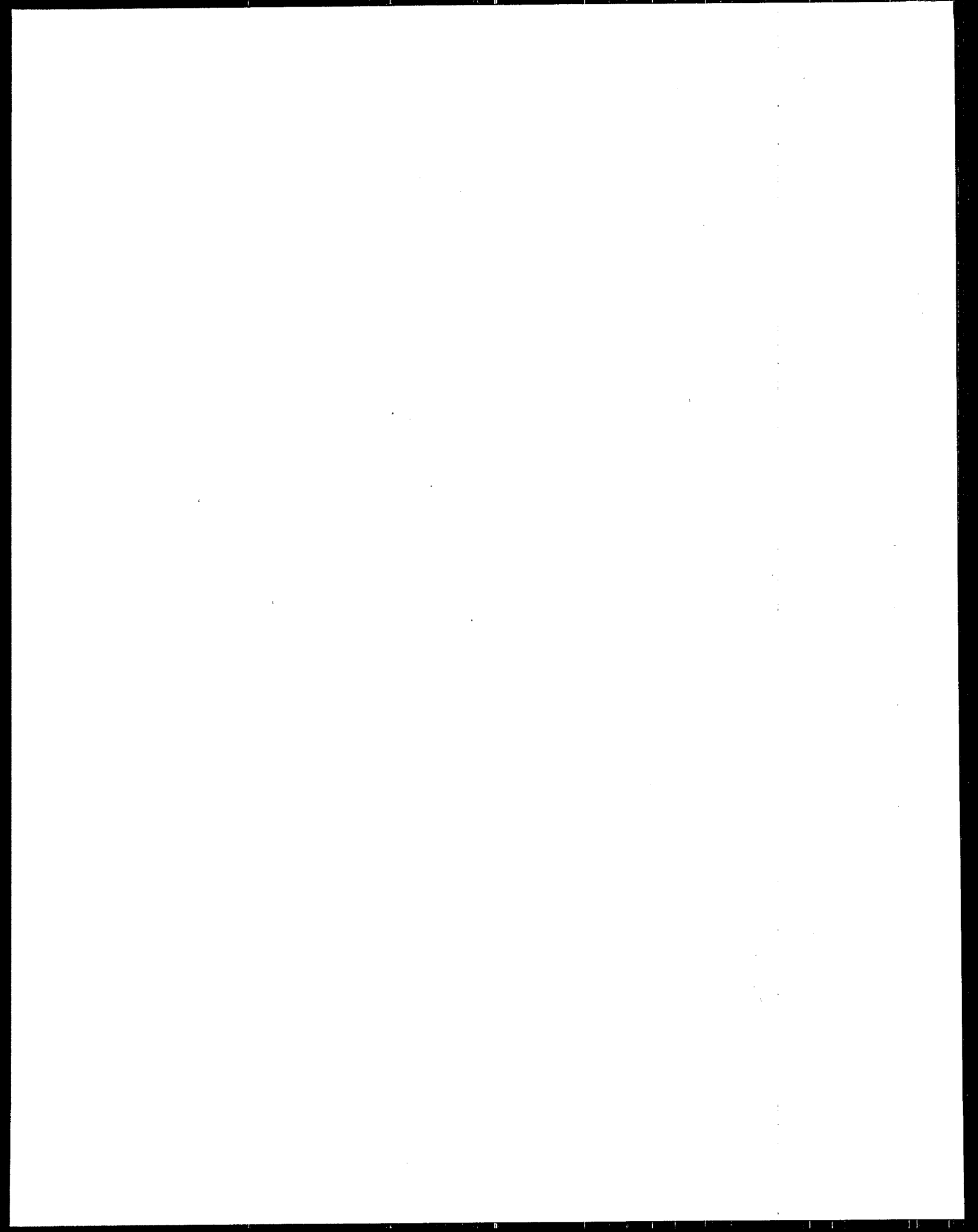
To order one or more tapes please complete the form on the reverse side of this sheet and mail it with your check made out to the order of "Foster Wheeler Enviroresponse, Inc." A check for prepayment of the total amount must accompany the order. FWEI will require 2-3 weeks to fulfill your request.

CONTENTS OF COMPOSITE TAPES

SITE Tape S1	SITE Tape S2	SITE Tape S3	RCB Research Tape R1
ECOVA (SHIRCO) INFRARED INCINERATION SYSTEM Brandon, FL - 8/87	ULTROX ULTRAVIOLET RADIATION AND OXIDATION San Jose, CA, 3/89	SOLIDITECH SOLIDIFICATION AND STABILIZATION Morganville, NJ - 12/88	SYNTHETIC SOILS MATRIX (SSM) PROGRAM
ECOVA (SHIRCO) INFRARED INCINERATION SYSTEM Rose Twp., MI - 11/87	BIOTROL BIOLOGICAL AQUEOUS TREATMENT New Brighton, MN - 9/89	CHEMFIX SOLIDIFICATION AND STABILIZATION Clackamas, OR - 3/89	DIOXIN AND THE MOBILE INCINERATION SYSTEM
EMTECH (HAZCON) SOLIDIFICATION PROCESS Douglasville, PA. - 10/87	BIOTROL SOIL WASHING SYSTEM New Brighton, MN - 9/89	NOVATERRA (TTUSA) IN SITU STEAM AND AIR STRIPPING San Pedro, CA - 9/89	MOBIL CARBON REGENERATION SYSTEM
IWT/GEO-CON IN SITU STABILIZATION/ SOLIDIFICATION Hialeah, FL - 4/88	IT/RREL DEBRIS WASHING SYSTEM Hopkinsville, KY - 12/89	AWD TECHNOLOGIES INTEGRATED VAPOR EXTRACTION/STEAM VACUUM STRIPPING Burbank, CA - 9/90	MOBILE SOILS WASHING SYSTEM
TERRA VAC VACUUM EXTRACTION SYSTEM Groveland, MA - 1/88			MOBILE IN SITU CONTAINMENT/ TREATMENT
CF SYSTEMS SOLVENT EXTRACTION UNIT New Bedford, MA - 3/89			

APPENDIX B

DEMONSTRATION PROGRAM PARTICIPANTS



SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
AccuTech Remedial Systems, Inc., Keyport, NJ (005)*	Pneumatic Fracturing Extraction and Catalytic Oxidation	Harry Moscatello 908-739-6444	Uwe Frank 908-321-6626	Soil, Rock	Not Applicable	Halogenated and Nonhalogenated VOCs and SVOCs
Allied-Signal Corporation, Morristown, NY (003)	ICB Biotreatment System	Ralph Nussbaum/ Tim Love 201-455-3190	Ronald Lewis 513-569-7856	Groundwater, Wastewater	Not Applicable	Readily Biodegradable Organic Compounds
American Combustion, Inc., Norcross, GA (001)	PYRETRON® Oxygen Burner	Gregory Gitman 404-564-4180	Laurel Staley 513-569-7863	Soil, Sludge, Solid Waste	Not Applicable	Non-Specific Organics
AWD Technologies, Inc., San Francisco, CA (004)	Integrated Vapor Extraction and Steam Vacuum Stripping	David Bluestein 415-227-0822	Norma Lewis/ Gordon Evans 513-569-7665/ 513-569-7684	Groundwater, Soil	Not Applicable	VOCs
Babcock & Wilcox Co., Alliance, OH (006)	Cyclone Furnace	Lawrence King 216-829-7576	Laurel Staley 513-569-7863	Solids, Soil	Non-Specific	Non-Specific Organics
Bio-Recovery Systems, Inc. ¹ , Las Cruces, NM (005)/(E01)	Biological Sorption	Godfrey Crane 505-523-0405	Naomi Barkley 513-569-7854	Groundwater, Electroplating Rinsewater	Heavy Metals	Not Applicable
BioTrol, Inc., Chaska, MN (003)	Biological Aqueous Treatment System	Dennis Chilcote/ Pamela Sheehan 612-448-2515/ 609-951-0314	Mary Stinson 908-321-6683	Liquid Waste, Groundwater	Nitrates	Chlorinated and Nonchlorinated Hydrocarbons, Pesticides
BioTrol, Inc., Chaska, MN (003)	Soil Washing System	Dennis Chilcote/ Pamela Sheehan 612-448-2515/ 609-951-0314	Mary Stinson 908-321-6683	Soil	Metals	High Molecular Weight Organics, PAHs, PCP, PCBs, Pesticides

* Solicitation number

1 Graduate of Emerging Technology Program

SITE Demonstration Program Participants

	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
BioVersal USA, Inc., Des Plaines, IL (005)	BioGenesis™ Soil Cleaning Process	Mohsen Amiran/ Charles Wilde 708-827-0024 703-250-3442	Annette Gatchett 513-569-7697	Soil	Not Applicable	Volatile and Nonvolatile Hydrocarbons, PCBs
CET Environmental Services – Sanivan Group, Montreal, Canada (005)	Soil Treatment With Extraksol™	Jean Paquin 514-353-9170	Mark Meckes 513-569-7348	Soil	Not Applicable	SVOCs, PCBs, PCPs, PAHs
CF Systems Corporation, Waltham, MA (002)	Solvent Extraction	Chris Shallice 617-937-0800	Laurel Staley 513-569-7863	Soil, Sludge, Wastewater	Not Applicable	PCBs, VOCs, SVOCs, Petroleum Wastes
Chemfix Technologies, Inc., Metairie, LA (002)	Solidification and Stabilization	Philip Baldwin 504-831-3600	Edwin Barth 513-569-7669	Soil, Sludge, Solids, Waste, Electroplating Wastes	Heavy Metals	High Molecular Weight Organics
Chemical Waste Management, Inc., Geneva, IL (006)	Dechlor/KGME	John North 708-513-4867	Paul dePercin 513-569-7797	Waste Streams, Soils	Not Applicable	Halogenated Aromatic Compounds, PBCs
Chemical Waste Management, Inc., Geneva, IL (005)	PO*WW*ER™ Evaporation and Catalytic Oxidation of Wastewater	Erick Newman 708-513-4500	Randy Parker 513-569-7271	Wastewater, Leachate, Ground Water	Metals, Volatile Inorganic Compounds, Salts	VOCs and Nonvolatile Organic Compounds
Chemical Waste Management, Inc., Geneva, IL (003)	X*TRAX™ Thermal Desorption remediation	Carl Swanstrom 708-513-4578	Paul dePercin 513-569-7797	Soil, Sludge, Other Solids	Not Applicable	VOVs, SVOCs, PCBs
Colorado Department of Health ² [developed by Colorado School of Mines], Denver, CO (005) (E01)	Wetlands-Based Treatment	Rick Brown 303-331-4404	Edward Bates 513-569-7774	Acid Mine Drainage	Metals	Not Applicable
Dames & Moore, Tallahassee, FL (005)	Hydrolytic Terrestrial Dissipation	Stoddard Pickrell 904-942-5615	Ronald Lewis 513-569-7865	Soil	Not Applicable	Low Level Toxaphene and Other Pesticides

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SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Dehydro-Tech Corporation, East Hanover, NJ (004)	Carver-Greenfield Process for Extraction of Oily Waste	Thomas Holcombe 201-887-2182	Laurel Staley 513-569-7863	Soil, Sludge	Not Applicable	PCBs, Dioxin, Oil-Soluble Organics
E.I. DuPont de Nemours and Co. and Oberlin Filter Co., Newark, DE, and Waukesha, WI (003)	Membrane Microfiltration	Ernest Mayer 302-366-3652	John Martin 513-569-7758	Groundwater, Leachate, Wastewater, Electroplating Rinsewaters	Heavy Metals, Cyanide, Uranium	Organic Particulates
Dynaphore, Inc./H ₂ O Company, Richmond, VA/Knoxville, TN (006)	Use of FORAGER™ Sponge To Remove Dissolved Metals	Norman Rainer 804-288-7109	Carolyn Esposito 908-906-6895	Industrial Discharge, Municipal Sewage Process Streams, Acid Mine Drainage Wastes	Metals	Aliphatic Organic Chlorides and Bromides
Ecova Corporation, Redmond, WA (006)	Bioslurry Reactor	William Mahaffey 206-883-1900	Ronald Lewis 513-569-7856	Soil	Not Applicable	Creosote
Ecova Corporation, Redmond, WA (003)	In Situ Biological Treatment	Michael Nelson 206-883-1900	Naomi Barkley 513-569-7854	Water, Soil, Sludge, Sediment	Not Applicable	Biodegradable Organics
Ecova Corporation, [developed by Shirco Infrared Systems, Inc.], Redmond, WA (001) [2 Demonstrations]	Infrared Thermal Destruction	John Cioffi 206-883-1900	Howard Wall 513-569-7691	Soil, Sediment	Not Applicable	Non-Specific Organics
ELI Eco Logic International, Inc., Rockwood, Ontario Canada (006)	Thermal Gas Phase Reduction Process	Jim Nash 519-856-9591	Gordon Evans 513-569-7684	Soil, Sludge, Liquids, Gases	Not Applicable	PCBs, PAHs, Chlorophenols, Pesticides
EmTech Environmental Services [formerly Hazcon, Inc.], Fort Worth, TX (001)	Chemical Treatment and Immobilization	Ray Funderburk 800-227-6543	Paul dePercin 513-569-7797	Soil, Sludge, Sediments	Heavy Metals	Non-Specific Organics
ENSITE, Inc., Tucker, GA (006)	Safesoil™ Biotreatment Process	Andrew Autry 404-934-1180	Doug Grosse 513-569-7844	Soil	Not Applicable	Petroleum Hydrocarbons, TCE, Aliphatic Solvents, PAHs

SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
EPOC Water, Inc., Fresno, CA (004)	Precipitation and Microfiltration, and Sludge Dewatering	Ray Groves 209-291-8144	S. Jackson Hubbard 513-569-7507	Sludge, Wastewater, Leachable Soil	Heavy Metals	Pesticides, Oil, Grease
Excalibur Enterprises, Inc., New York, NY (004)	Soil Washing and Catalytic Ozone Oxidation	Lucas Boeve/ Gordon Downey 809-571-3451/ 303-752-4363	Norma Lewis 513-569-7665	Soil, Sludge, Leachate, Groundwater	Cyanide	SVOCs, Pesticides, PCBs, PCP, Dioxin
Exxon Chemicals, Inc. and Rio Linda Chemical Co., Long Beach, CA (004) [2 Demonstrations]	Chemical Oxidation and Cyanide Destruction	Denny Grandle 713-406-6816	Teri Shearer 513-569-7949	Groundwater, Wastewater, Leachate,	Cyanide	Non-Specific Organics
Filter Flow Technologies, Inc., League City, TX (006)	Heavy Metals and Radionuclide Filtration	Tod Johnson 713-334-2522	Annette Gatchett 513-569-7697	Groundwater, Industrial Wastewater	Heavy Metals, Radionuclides	Not Applicable
GeoSafe Corporation, Kirkland, WA (002)	In Situ Vitrification	James Hansen 206-822-4000	Teri Shearer 513-569-7949	Soil, Sludge	Non-Specific Inorganics	Non-Specific Organics
Hazardous Waste Control, Fairfield, CT (006)	NOMIX® Technology	David Babcock 203-336-7955	Teri Shearer 513-569-7949	Drum Waste, Waste Lagoons, Spills	Metals	Not Applicable
Horsehead Resources Development Co., Inc., Monaca, PA (004)	Flame Reactor	Regis Zagrocki 412-773-2289	Donald Oberacker/ Marta Richards 513-569-7510/ 513-569-7783	Soil, Sludge, Industrial Solid Residues	Metals	Not Applicable
Hughes Environmental Systems, Inc., Manhattan Beach, CA (005)	Steam Injection and Vacuum Extraction	John Dablow 213-536-6548	Paul dePercin 513-569-7797	Soil, Groundwater	Not Applicable	VOCs and SVOCs
In-Situ Fixation Co., Chandler, AZ (005)	Deep In Situ Bioremediation	Richard Murray 602-821-0409	Edward Opatken 513-569-7855	Soil, Sludge	Not Applicable	Biodegradable Organics
International Environmental Technology, Perrysburg, OH (005) (2 Demonstrations)	Geolock/Bio-drain Treatment	Lynn Sherman 419-856-2001	Randy Parker 513-569-7271	Soil	Not Applicable	Biodegradable Organics

SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
International Waste Technologies and Geo-Con, Inc., Wichita, KS (001)	In Situ Solidification and Stabilization	Jeff Newton/ Brian Jasperse 316-269-2660/ 412-856-7700	Mary Stinson 908-321-6683	Soil, Sediment	Non-Specific Inorganics	PCBs, PCP, Other Non-Specific Organics
Maecorp, ³ Chicago, IL (006)	MAECTITE Treatment Process	Karl Yost 213-372-3300	S. Jackson Hubbard 513-569-7507	Soil, Sludge, Lead Battery Sites	Metals	Non-specific Organics
NOVATERRA, Inc. (formerly Toxic Treatments USA, Inc.), Torrance, CA (003)	In Situ Steam and Air Stripping	Philip LaMori 310-328-9433	Paul dePercin 513-569-7797	Soil	Not Applicable	VOCs, SVOCs, Hydrocarbons
Ogden Environmental Services, San Diego, CA (001)	Circulating Bed Combustor	Sherin Sexton 619-455-4622	Douglas Grosse 919-541-7844	Soil, Sludge, Slurry, liquids	Not Applicable	Halogenated and Nonhalogenated Organic Compounds, PCBs
Peroxidation Systems, Inc., Tucson, AZ (006)	perox-pure™	Chris Giggy 602-790-8383	Norma Lewis 513-569-7665	Groundwater, Wastewater	Not Applicable	Fuel Hydrocarbons, Chlorinated Solvents, PCBs
Purus, Inc., San Jose, CA (006)	Photolytic Oxidation Process	Paul Blystone 408-453-7804	Norma Lewis 513-569-7665	Groundwater	Not Applicable	Fuel Hydrocarbons
QUAD Environmental Technologies Corp., Northbrook, IL (004)	Chemtact™ Gaseous Waste Treatment	Robert Rafson 312-564-5070	Ronald Lewis 513-569-7856	Gaseous Waste Streams	Non-Specific Inorganics	Volatile Organics
Recycling Sciences International, Inc., Chicago, IL (004)	Desorption and Vapor Extraction System	Mark Burchett 312-559-0122	Laurel Staley 513-569-7863	Soil, Sludge, Sediment	Volatile Inorganics	VOCs and SVOCs including PCBs, PAHs, PCP, some Pesticides
Remediation Technologies, Inc., Pittsburgh, PA (006)	High Temperature Thermal Processor	David Nakles 412-826-3340	Ronald Lewis 513-569-7856	Soils, Sediments, Sludges	Mercury	VOCs and SVOCs
Remediation Technologies, Inc., Seattle, WA (002)	Liquid and Solids Biological Treatment	Merv Cooper 206-624-9349	Ronald Lewis 513-569-7856	Soil, Sludge,	Not Applicable	Biodegradable Organics, Pesticides

3 This technology is not profiled in the Demonstration section.

SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Resources Conservation Co., Ellicott City, MD (001)	Solvent Extraction	Lanny Weimer 301-596-6066	Mark Meckes 513-569-7348	Soil, Sludge	Not Applicable	Oil, PCBs, PAHs
Retech, Inc., Ukiah, CA (002)	Plasma Arc Vitrification	R. C. Eschenbach 707-462-6522	Laurel Staley 513-569-7863	Soils, Sludge	Metals	Non-Specific Organics
Risk Reduction Engineering Laboratory, Cincinnati, OH (006)	Base-Catalyzed Dechlorination Process	Chris Rogers 513-569-7626	Laurel Staley 513-569-7863	Soils, Sediments	Not Applicable	PCBs, PCPs
Risk Reduction Engineering Laboratory, Cincinnati, OH (006)	Bioventing	Paul McCauley 513-569-7444	Mary Gaughan 513-569-7341	Soil	Not Applicable	Biodegradable Organics
Risk Reduction Engineering Laboratory and IT Corporation Cincinnati, OH (004)	Debris Washing System	Michael Taylor 513-782-4700	Naomi Barkley 513-569-7854	Debris	Non-Specific Inorganics	Non-Specific Organics, PCBs, Pesticides
Risk Reduction Engineering Laboratory and University of Cincinnati, Cincinnati, OH (005)	Hydraulic Fracturing	Larry Murdoch 513-569-7897	Naomi Barkley 513-569-7854	Soil	Non-specific Inorganics	Non-specific Organics
Risk Reduction Engineering Laboratory and USDA Forest Products Laboratory, Cincinnati, OH (006)	Fungal Treatment Technology	Richard Lamar 608-231-9469	Kim Lisa Kreiton 513-569-7328	Soil	Not Applicable	PCPs, PAHs, Chlorinated Organics
Rochem Separation Systems, Inc., Torrance, CA (006)	Rochem Disc Tube Module System	David LaMonica 213-370-3160	Douglas Grosse 513-569-7844	Liquids	Non-Specific Inorganics	Organic Solvents
SBP Technologies, Inc., Stone Mountain, GA (005)	Membrane Separation and Bioremediation	Heather Ford 404-498-6666	Kim Lisa Kreiton 513-569-7328	Groundwater, Soils, Sludges	Not Applicable	Organic Compounds, PAHs, PCBs, TCEs
S.M.W. Seiko, Inc., Redwood City, CA (004)	In Situ Solidification and Stabilization	David Yang/ Osamu Taki 415-591-9646	S. Jackson Hubbard 513-569-7507	Soil	Metals	SVOCs, PCBs, PAHs

SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Separation and Recovery Systems, Inc., Irvine, CA (002)	SAREX Chemical Fixation Process	Joseph DeFranco 714-261-8860	S. Jackson Hubbard 513-569-7507	Sludge, Soil	Low Level Metals	Non-specific Organics
Silicate Technology Corp., Scottsdale, AZ (003)	Solidification and Stabilization Treatment Technology	Steve Pelger/ Scott Larsen 602-948-7100	Edward Bates 513-569-7774	Soil, Sludge, Wastewater	Metals, Cyanide, Ammonia	High Molecular Weight Organics
SoilTech, Inc., Englewood, CO (005) (2 Demonstrations)	Anaerobic Thermal Processor	Martin Vorum 303-790-1747	Paul dePercin 513-569-7797	Soil, Sludge, Refinery Wastes	Not Applicable	PCBs, Chlorinated Pesticides, VOCs
Soliditech, Inc., Houston, TX (002)	Solidification and Stabilization	Bill Stallworth 713-497-8558	S. Jackson Hubbard 513-569-7507	Soil, Sludge	Metals	Non-Specific Organics
TechTran, Inc., Houston, TX (005)	Chemical Binding, Precipitation and Physical Separation	Charles Miller/ C. P. Yang 713-896-4343	Annette Gatchett 513-569-7697	Aqueous Solutions	Heavy Metals, Radionuclides	Non-Specific
Terra-Kleen Corporation, Oklahoma City, OK (006)	Soil Restoration Unit	Alan Cash 405-728-0001	Mark Meckes 513-569-7348	Soil	Not Applicable	PCBs, PCPs, Creosote, Chlorinated Solvents, Naphthaline, Diesel Oil, Used Motor Oil, Jet Fuel, Grease, Organic Pesticides
Terra Vac, Inc., San Juan, PR (001)	In Situ Vacuum Extraction	James Malot 809-723-9171	Mary Stinson 908-321-6683	Soil	Not Applicable	VOCs and SVOCs
Texaco Syngas, Inc., White Plains, NY (006)	Entrained-Bed Gasification	Richard Zang 914-253-4047	Marta Richards 513-569-7783	Soils, Sludges, Sediments	Not Applicable	Non-specific Organics
TEXAROME, Inc., Leakey, TX (006)	Mobile Solid Waste Desorption	Gueric Boucard 512-232-6079	Mary Gaughan 513-569-7341	Soils, Wood Wastes, Mop-up Materials	Volatile Inorganics	VOCs, SVOCs, PCBs, PCPs, Creosote, Organic Fungicides, Pesticides
Udell Technologies, Inc., Emeryville, CA (005)	In Situ Steam Enhanced Extraction	Lloyd Steward 510-653-9477	Paul dePercin 513-569-7797	Soils, Ground Water	Not Applicable	VOCs and SVOCs, Hydrocarbons, Solvents

SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Ultrax International, Inc., Santa Ana, CA (003)	Ultraviolet Radiation and Oxidation	Jerome Barich 714-545-5557	Norma Lewis 513-569-7665	Groundwater, Leachate, Wastewater	Not Applicable	Halogenated Hydrocarbons, VOCs, Pesticides, PCBs
U.S. Environmental Protection Agency	Excavation Techniques and Foam Suppression Methods	Dick Gerstle 513-782-4700	S. Jackson Hubbard 513-569-7507	Soil	Volatile Inorganics	Volatile Organics
Wastech Inc., Oak Ridge, TN (004)	Solidification and Stabilization	E. Benjamin Peacock 615-483-6515	Edward Bates 513-569-7774	Soil, Sludge, Liquid Waste	Non-Specific, Radioactive	Non-Specific Organics
Western Research Institute ⁴ , Laramie, WY (005) (E01)	Contained Recovery of Oily Wastes	James Speight 307-721-2011	Eugene Harris 513-569-7862	Soil	Not Applicable	Coal Tar Derivatives, Petroleum Byproducts
Weston Services, Inc., West Chester, PA (006)	Low Temperature Thermal Treatment (LT ³ ®)	Mike Cosmos 215-430-7423	Paul dePercin 513-569-7797	Soil	Not Applicable	VOCs and SVOCs
Zimpro/Passavant, Environmental Systems, Inc., Rothschild, WI (002)	PACT® Wastewater Treatment System	William Copa 715-359-7211	John Martin 513-569-7758	Groundwater, Industrial Wastewater, Leachate	Not Applicable	Biodegradeable VOCs and SVOCs

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APPENDIX C

EMERGING TECHNOLOGY PROGRAM PARTICIPANTS

SITE Emerging Technology Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
ABB Environmental Services, Inc., Wakefield, MA (E03)*****	Two-Zone Plume Interception In Situ Treatment Strategy	Sam Fogel 617-245-6606	Ronald Lewis 513-569-7856	Solids, Liquids	Not Applicable	Chlorinated and Nonchlorinated Solvents
Alcoa Separations, Warrendale, PA (E03)	Bioscrubber	Paul Liu 412-772-1332	Naomi Barkley 513-569-7854	Soil, Water, Air	Not Applicable	Most Organics
Allis Mineral Systems, Inc., [formerly Boliden Allis, Inc.,] Milwaukee, WI (E03)	Pyrokiln Thermal Encapsulation Process	John Lees 414-475-3862	Marta Richards 513-569-7783	Soil, Sludge	Most Metallic Compounds	Most Organics
Atomic Energy of Canada, Ltd., Chalk River, Ontario (E01)	Chemical Treatment and Ultrafiltration	Leo Buckley 613-584-3311	John Martin 513-569-7758	Groundwater	Heavy Metals	Not Applicable
Babcock & Wilcox Co., Alliance, OH (E02)	Cyclone Furnace	Lawrence King 216-829-7576	Laurel Staley 513-569-7863	Solids, Soil	Non-Specific Inorganics	Non-Specific Organics
Battelle Memorial Institute, Columbus, OH (E01) [Project completed]	In Situ Electroacoustic Decontamination	Satya Chauhan 614-424-4812	Jonathan Herrman 513-569-7839	Soil	Heavy Metals	Not Applicable
BioTrol, Inc., Chaska, MN (E03)	Methanotrophic Bioreactor System	Jeffery Petola 612-448-2515	David Smith 513-569-7856	Water	Not Applicable	Halogenated Hydrocarbons
Bio-Recovery Systems, Inc. ¹ , Las Cruces, NM (E01) [Project completed]	Biological Sorption	Dennis Darnall 505-646-5018	Naomi Barkley 513-569-7854	Groundwater, Leachate, Wastewater	Heavy Metals	Not Applicable
Center for Hazardous Materials Research, Pittsburgh, PA (E03)	Acid Extraction Treatment System	Stephen Paff 412-826-5320	Kim Lisa Kreiton 513-569-7328	Soil	Heavy Metals	Not Applicable

***** Solicitation number

¹ Graduate of Emerging Technology Program

SITE Emerging Technology Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
New Jersey Institute of Technology, Newark, NJ (E03)	Ghea Associates Process	Itzhak Gotlieb 201-596-5862	Annette Gatchett 513-569-7697	Mixtures	Most Inorganics	Most Organics
Nutech Environmental, London, Ontario (E04)	Photocatalytic Oxidation	Brian Butters 519-457-1676	John Ireland 513-569-7413	Wastewater, Groundwater, Air-streams	Cyanide, Sulphite, Nitrite Ions	PCBs, PCDDs, PCDFs, Chlorinated alkenes, Chlorinated phenols,
PSI Technology Company, Andover, MA (E04)	Metals Immobilization and Decontamination of Aggregate Solids	Srivats Srinvasachar 508-689-0003	Mark Meckes 513-569-7384	Soils, Sediments, Sludges	Heavy Metals	Most Organics
Pulse Sciences, Inc., Agoura Hills, CA (E04)	X-Ray Treatment	John Bayless/ Randy Curry 818-707-0095/ 415-632-5100	Esperanza Renard 513-569-7328	Soil, Water	Not Applicable	PCBs, TCE, TCA, Benzene
Purus, Inc., San Jose, CA (E04)	Photolytic Oxidation Process	Paul Blystone 408-453-7804	Norma Lewis 513-569-7665	Soil, Groundwater	Not Applicable	VOCs
J.R. Simplot Company, Boise, ID (E03)	Anaerobic Biological Process	Douglas Sell 208-389-7265	Wendy Davis-Hoover 513-569-7206	Soil, Sludge	Not Applicable	Nitroaromatics
Trinity Environmental Technologies, Inc., Mound Valley, KS (E03)	Ultrasonically Assisted Detoxification of Hazardous Materials	Duane Koszalka 316-328-3222	Kim Lisa Kreiton 513-569-7328	Solids	Not Applicable	PCBs and Other Chlorinated Compounds
University of South Carolina, Columbia, SC (E03)	In Situ Mitigation of Acid Water	Frank Caruccio 803-777-4512	Roger Wilmoth 513-569-7509	Acid Drainage	Most Metals	Not Applicable
University of Washington, Seattle, WA (E02)	Adsorptive Filtration	Mark Benjamin 206-543-7645	Norma Lewis 513-569-7665	Groundwater, Leachate, Wastewater	Metals	Not Applicable
Vortec Corporation, Collegeville, PA (E04)	Oxidation and Vitrification Process	James Hnat 215-489-2255	Teri Shearer 513-569-7949	Soil, Sediments, Mill Tailings	Metals	Most Organics

SITE Emerging Technology Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Warren Spring Laboratory, Herts, England (E04)	Physical and Chemical Treatment	D. Neil Collins 01-44-438-7411 22 ext. 752	Mary Stinson 908-321-6683	Soil	Metals	Petroleum Hydrocarbons, PAHs
Wastewater Technical Centre, Burlington Ontario (E02)	Cross-Flow Pervaporation System	Rob Booth/ Pierre Côté 416-336-4689/ 416-639-6320	John Martin 513-569-7758	Groundwater, Leachate, Wastewater	Not Applicable	VOCs, Solvents, Petroleum Hydrocarbons
Western Product Recovery, Group, Inc. Houston, TX (E04)	CCBA Physical and Chemical Treatment	Donald Kelly 713-493-9321	Joseph Farrell 513-569-7645	Wastewater, Sludges, Sediments, Soil	Heavy Metals	Most Organics
Western Research Institute, ³ Laramie, WY (E01) [Project Completed]	Contained Recovery of Oily Wastes	James Speight 307-721-2011	Eugene Harris 513-569-7862	Soil	Not Applicable	Coal Tar Derivatives, Petroleum Byproducts

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